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[Teorìâ ta Metodika Fìzičnogo Vihovannâ]

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ORIGINAL SCIENTIFIC ARTICLE

THE EFFECTIVENESS OF E-LEARNING-BASED VOLLEYBALL SERVICE VIDEO MEDIA ON STUDENTS AFFECTED BY COVID-19 AT FACULTY OF SPORTS SCIENCE, UNIVERSITAS NEGERI MEDAN

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

The study purpose. The online learning system, media, and resources used by lecturers to achieve volleyball learning goals are known to be not optimal. This study aimed to develop an e-learning video media that can be used by students as a learning resource to learn the material for upper serve, jump serve, and floating serve in volleyball games.

Materials and methods. The research subjects were students who were divided into treatment groups and control groups where each group consisted of 40 people. The research method used was an experimental method with a before-after research design (one-group pretest and posttest design). A rubric test is an instrument used to measure the effectiveness of video media in improving student service skills.

Results. The results of the research and data analysis found that the service skills (upper serve, jump serve, and floating serve) in the treatment group with the help of e-learning video media were better than in the control group who did not receive e-learning.

Conclusions. The treatment group has better service skills than the control group. During the Covid-19 pandemic, it is recommended for lecturers to use e-learning video media in teaching volleyball service material.

Keywords: media e-learning, volleyball serve.

Introduction

The study of Physical Education, Health and Recreation is closely related to the subject matter studied by students in this course. These materials include all the basic techniques in sports, such as service techniques, passing, smashes, blocking, rules and refereeing (Vute, 2009). The purpose of students studying this course is so that they can master the various subject matter. Therefore, after they graduate from college, they are expected to become teachers who can teach volleyball to students at school. Based on the E-Learning web-site and the network teaching, we use skilled system to establish the interactive Sport Teaching E-Learning structure (Chang, 2008) To achieve this goal, a lecturer is required to be able to provide meaningful learning patterns and following the needs of students. The pattern of learning volleyball courses conducted by lecturers so far is through direct learning (face to face) in which there is the direct interaction between lecturers and students at the same time and place (Fathoni, 2018). The achievement of volleyball learning objectives through the direct learning pattern obtained excellent student results. Since Covide-19 is greatly affected Indonesian, the government is taking policy steps with regional lockdown in Indonesia (Pardilla et al., 2020). The Covid-19 pandemic outbreak that hit Indonesia caused direct learning patterns to be impossible to do. In other words, students cannot learn directly with their lecturers. This in the end becomes a problem that needs to be addressed by lecturers and students. This problem can be solved if changes and adjustments are made to the learning patterns of lecturers with the conditions during the Covid-19 pandemic.

Regulation of the Minister of Education of the Republic of Indonesia Number 3 of 2020 concerning Prevention of Covid-19 in education units aims to assist teachers and students in carrying out the teaching and learning process

even though it is not done face-to-face. Thus, one alternative that can be done to overcome the problems described previously is to conduct distance learning in the network. Distance learning in this network is learning on the internet network using e-learning media (Denysova et al., 2018). Through this e-learning media, lecturers and students can do face-to-face online as a teaching and learning interaction related to volleyball material. This e-learning media content is equipped with video-based learning resources, tutorials on basic volleyball techniques, and forms of practice. Students will be able to study the content on their own (self-check) and learn from the videos supplied from the comfort of their own homes (Invernizzi et al., 2019).

Service in volleyball is a technique to start a game. The definition of service is an attempt to cross the ball over the net every time it serves (Ahmadi, 2008). The service in volleyball is divided into five types, namely under service, side hard service, overhead service, floating service, upper spin service, and jump service. The under serve can be referred to as a service for novice players. As mentioned by (Beutelstahl, 2016) that the underserved is the most popular and most frequently used service considering that this service is the easiest serve where the ball can be controlled more accurately than other services. The advantage of the underserved is that it is easy to do, while the drawback of this serve is that the ball bounces high so that it is easily accepted by the opponent (Barbara et al., 2000). The description of the implementation of the volleyball underhand service can be explained as follows.

The implementation of this service begins from the preparation stage with a standing position, left foot in front with a slightly bent knee, right leg back straight, body slightly leaning forward, and body weight on the left leg/front leg (Kumar et al., 2021). Another position that needs to be considered is the left hand holding the ball in front of the body and the right hand straight back with the fingers together and the palm bent. This is followed by the hit stage, which is when the ball is thrown with the left hand up, then the right hand must be swung straight from the back to the front through the bottom beside the body and hit or touch the ball, followed by the right foot being stepped forward after the ball is hit (Aip Syarifuddin dan Muhadi, 1992).

Barbara et al. (2000), state that the upper service is a floating service. This is because the ball being hit will result in a left-right and up-down motion as it moves across the net. This happens because the ball is hit without turning. According to (Nuril Ahmadi, 2007), it is called a floating service because the ball that is hit by the service does not contain rotation (the ball goes floating or floating). The advantage of floating serve is that the ball is difficult to receive by opposing players because the ball does not move in one trajectory and the ball speed is unpredictable (Lopez-Martinez & Palao, 2009). On the other hand, the weakness is that it is not powerful, sometimes the ball moves too high up to leave the field. The description of the implementation of the above service can be explained below.

The upper service is carried out in three stages (Barbara et al., 2000), namely; (1) Preparation Stage; feet in a relaxed stride position, bodyweight is evenly distributed, shoulders parallel to the net, feet of the hand that is not hitting are in front then use open palms, and eyes on the ball. (2) Implementation Phase; hit the ball in front of the shoulder of the hitting arm, hit the ball without or with little spin, hit the ball with one hand, hit the ball close to the body, swing the arm back with the elbow up, place the hand near the ear, hit the ball with the heel of the palm open, keep the arms in a position to reach as far as possible. Keep an eye on the ball when it is about to hit and shift your weight forward. (3) Continuation movement; keep the weight forward, lower the arms slowly as a follow-up to then move onto the court. It's not easy to master the upper serve technique so it takes practice over and over again. Besides, it is necessary to get the right, interesting and balanced method of exercise. Strengthening service skills is not enough just to train the technique, but also requires physical exercise which is also a major factor. Jump serve is a service by making a jump so that the opponent is difficult to deal with. The motion element of this technique is to combine the pressure, strength, and feeling of the player on the ball used in the game (Gabbett et al., 2006). This technique is the same as doing a smash, but it is done from a distance of 9 meters according to the length of the field against the net. Mastery of this technique is more emphasized on the feeling and experience of the player (Alwan, 2021). This technique is a combination of full spin, half spin and jump flute techniques. A player who uses this technique must be an experienced player, has good power, and have an adequate ball feeling. Someone who has good power can do this technique, but not all serves will work perfectly.

Arsyad (2004) states that learning media is a tool in the learning process both inside and outside the classroom. In the Regulation of the Minister of National Education of the Republic of Indonesia number 24 of 2007, it is stated that learning media are educational equipment used to assist communication in learning. Gagne (2012) explain that what is included in learning media are physical tools that can be used to convey the contents of teaching materials, such as books, tape recorders, cassettes, video cameras, video recorders, films, slides, photos, pictures, graphics, television, and computers. Media in the learning process serves as a presenter of stimuli (information, attitudes, etc.) and increases harmony in receiving information. In certain cases, the media is also useful for managing progress steps and providing feedback. However, other research, focusing on the educational impact of media, suggests that well-designed and age-appropriate educative media can impart knowledge (Mares & Pan, 2013). Furthermore, Hamalik (1982) revealed that "the use of instructional media in the teaching and learning process can generate motivation and stimulation of learning activities and even bring psychological effects on students.

Agus S. Suryobroto (2001) stated that the use of media is the use of learning resources that must be systematic where the decision to try or use learning resources must pay attention to the characteristics of students and learning objectives. Aside from the characteristics of educational media that influence learning, researchers have also examined the personal characteristics of learners such as demographics, age, and gender (Kirkorian & Anderson, 2008). The E-learning experience of students is significantly correlated with the learning process and has an indirect effect on perceived learning outcomes (Azis, Suharyati, & Susanti, 2019). The use of interactive features of e-learning increases the motivation of the undergraduate students for the learning process (Abou El-Seoud et al., 2014).

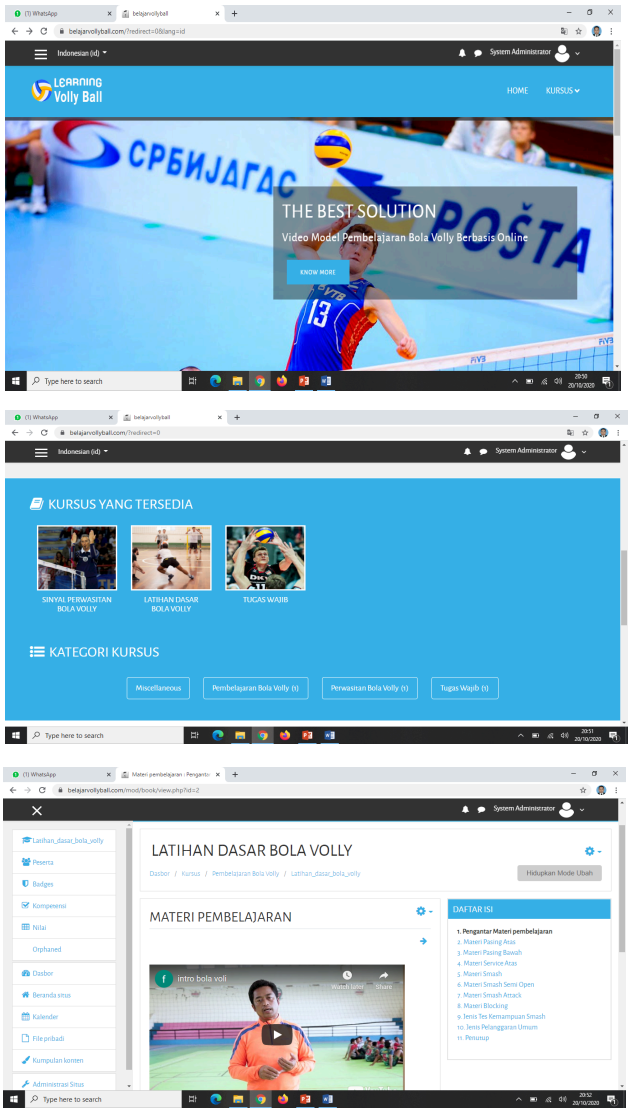

Figure 1. E-learning volleyball.com Web Display

In developing students' movement skills, educators also need to develop media that can attract students' interest and attention to foster their motivation, creativity, and movement activities. When this can be conditioned by the lecturer, the achievement of the volleyball service learning objectives will be more optimal. As stated (Samsuddin Siregar, 2020), learning activities with well-designed games in a learning process will provide many benefits for students and educators.

E-learning transitions from computer-managed learning to collaborative online learning by utilizing new technological platforms like as Edmodo, Social media, Blog, Coursera, or HEIs-specific tools (Sukendro et al., 2020). The media used in this study were the e-learning volleyball.com Web and volleyball service video media. The volleyball.com e-learning web was developed as an online learning space for lecturers and students. Through the web, lecturers and students can interact to review conceptually related to volleyball service technique practices, hold discussions and questions and answers, conduct quizzes, and make reports on their mandatory assignments (routine assignments, critical book-review assignments, critical journal review assignments, engineering assignments). ideas, research mini assignments, and project assignments). The screen display of the volleyball.com e-learning web is presented in Figure 1.

The demonstration of the movements shown in the video has been accompanied by an explanation from the instructor regarding the meaning of each of the movements demonstrated. The video has also been equipped with a variety of exercises that can be a reference for students to practice their skills independently. In research findings by (Palao, 2012), it is stated that "The 'video and teacher feedback' condition provided the most positive overall results (Fukkink et al., 2011), with statistically significant improvements in skill execution, technique, and knowledge learning, as well as the highest level of practice. Nonetheless, while acknowledging the utility of video feedback as an instructional tool, the teacher felt overwhelmed by the demands of the technology on both his time commitments and in terms of his technology competencies. *The study purpose* to develop an e-learning video media that can be used by students as a learning resource to learn the material for upper serve, jump serve, and floating serve in volleyball games.

Materials and methods

Study participants

Based on figure one, it can be explained that four steps are passed in the design of this research. The first step is a random sampling from the population (80 students) to determine 40 people who will then be put into the treatment group and 40 people into the conventional group.

Study organization

This research was conducted online from the home of the researcher and research subject (Learning From Home) starting from September 7, 2020, to October 7, 2020.

Table 1. Service Learning Schedule

Part	Sept-Oct 2020 Time (Western Indonesian Time)	Group	
		Treatment	Control
1	10.00-11.50	Media e-learning service	Conventional
2	10.00-11.50	Media e-learning service	Conventional
3	10.00-11.50	Media e-learning service	Conventional

An experimental method was used for this study. It aimed to test the effectiveness of e-learning media in improving students' volleyball service skills. The design used in this study was a before-after experimental research design (one-Group pre-test and posttest design) (Sugiono, 2008). For more details, see Figure 2 below.

Based on figure one, it can be explained that four steps are passed in the design of this research. The first step is a random sampling from the population (80 students) to determine 40 people who will then be put into the treatment group and 40 people into the conventional group. The second step is the pre-test. This aims to find out the initial data on student service skills. The third step is the process of

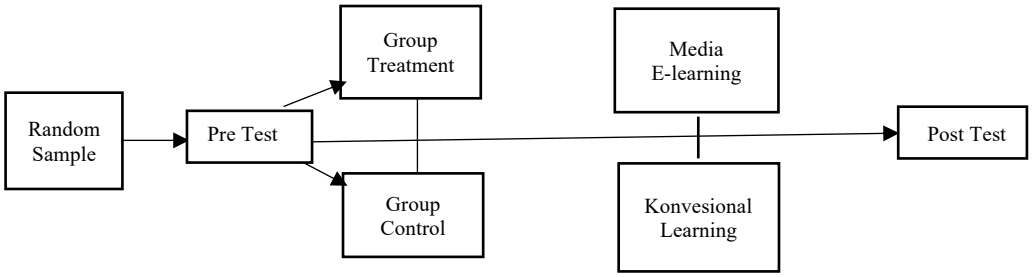

Figure 2. One-Group Pre-Test And Postest Design

learning the volleyball service itself. In this case, the service-learning treatment group does it online using e-learning media, while the conventional group also learns it online but uses conventional media (WhatsApp, email, youtube)

Statistical analysis

The fourth step is to do a post-test to find out the final data of the study. The instrument used in this study is the service assessment rubric. This scoring rubric is a scoring tool to check the correctness of the service movement. The data obtained were then analyzed using the SPSS 21 application.

Results

The treatment group is students who learn to serve volleyball by using the volleyball.com e-learning application. On the volleyball.com web, videos of volleyball lessons have been provided for students to study independently. In the control group, the learning activities were carried out in a conventional way where teaching materials and learning resources were obtained by the students themselves. In other words, the lecturer did not prepare teaching materials and learning resources for the control group.

Before the service-learning action was carried out in the two groups, a pre-test was carried out first to determine the student's initial abilities. After the learning activity is carried out, it is continued with the post-test. Post-tests aim to determine the final ability of students.

Research findings on basic volleyball service techniques based on data analysis (SPSS 21) pre-test and post-test are presented in the following table and diagram.

Table 2. Data Analysis of Top Service

Descriptive Statistics					
Indicators	**N**	**Min**	**Max**	**Mean**	**Std. Dev.**
Pre-Test Treatment	40	4	7	5.73	.784
Post-Test Treatment	40	9	12	10.92	1.185
Pre-Test Control	40	4	7	5.52	.784
Post-Test Control	40	8	12	10.18	1.035
Valid N (listwise)	40				

The difference in the average achievement of students from the two groups in the post test service is presented in the diagram above. The treatment group obtained an average of 10.92, while the control group obtained an average of

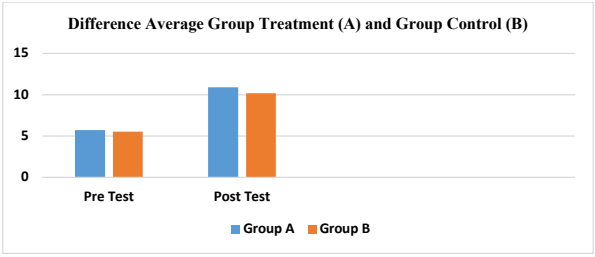

Figure 3. Difference Average Among Group

10.18. Based on the average data, it indicates that the value obtained by students in the treatment group is higher than the control group. In other words, it can be stated that learning upper service techniques through volleyball.com web and video media is better in improving students' service skills. The findings obtained related to the volleyball jump serve research based on data analysis (SPSS 21) pre-test and post-test are presented in the following table and diagram.

Table 3. Data Analysis of Jump Serve Data

Descriptive Statistics					
Indicators	**N**	**Min**	**Max**	**Mean**	**Std. Dev.**
Pre-Test Treatment	40	3	6	4.32	1.141
Post-Test Treatment	40	9	12	10.68	1.185
Pre-Test Control	40	3	6	4.35	1.145
Post-Test Control	40	7	12	10.25	1.149
Valid N (listwise)	40				

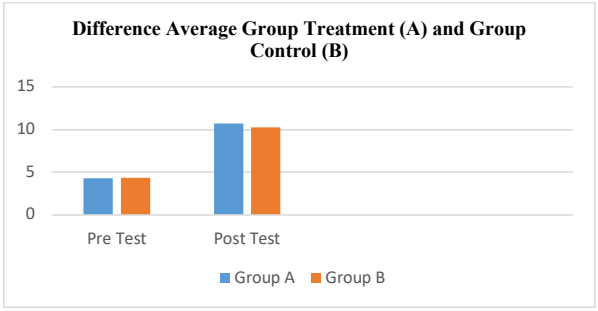

Figure 4. Difference Average Between Groups

Based on the diagram above, it can be seen the difference in the average post-test jump serve data for the two groups. The treatment group obtained an average of 10.68, while the control group obtained an average of 10.25. This

indicates that the average score of the treatment group is higher than the control group. Thus, it can be stated that learning the jump serve technique using volleyball.com web and video media is better in improving student service skills. Integrating volleyball.com web media and video media in learning is the right solution for lecturers who want to teach volleyball in situations or during the Covid-19 pandemic.

Discussion

Through the help of volleyball.com web and video media, lectures between lecturers and students can still be carried out properly without being hindered by place and time, even though face-to-face lectures cannot be carried out. the benefits of using instructional videos to supplement and improve lecture delivery.The course instructor gathered, evaluated, filtered, or created the instructional videos to have the same content as the classroom lecture materials and to fit the course learning goals (El-Ariss et al., 2021). The existence of the web also provides opportunities for students to learn more because whenever and wherever students are, they will always be able to access various existing materials (Trakru & Jha, 2019). Collaboration and engagement with peers and facilitators (lectures or instructors) in educational designs can give a focused space for reflecting on practice and empathetic adjustment of subject matter, which automated methods cannot. As a result, when the ultimate objective is to develop e-Learning that enhances learning retention and work performance, the efficacy of e-Learning may be properly measured by the quality of the interactions offered (Noesgaard & Ørngreen, 2015).

The interactive feature is also provided by the e-learning platform paradigm. People who can receive comments and see the learning outcomes of the E-learning platform (Chang, 2008). The web not only provides students with more opportunities, but the learning demonstration videos provided on the web will also help them to master the basic volleyball serve technique material. This is because the movements shown in the video are very easy for students to understand and follow so it is hoped that it will minimize the difficulties that students may have in carrying out the movements of every basic volleyball technique. Regarding the integration of video in learning, research was previously conducted by (Hee Jun Choi, 2005). Enhance usability assessments and e-learning tutorials, the main objective of which is to encourage physical performance-based learning (Hornbæk et al., 2018)

E-learning students had considerably higher intrinsic motivation than traditional classroom learners (Rovai et al., 2007). The paradigm of flow captures the peak experiences of intrinsic motivation, and most flow experiences happened when actively engaged in a hard task; consequently, this understanding should be applied to the usage of e-learning (Lee, 2010).This study implies that context-based videos in online courses have the potential to enhance learners' retention and motivation. In addition, the learners reported that the video-based instruction was more memorable than traditional text-based instruction. The usage of particular instructional videos in classrooms has a favorable influence on the learning process of specific movement skill performance (Born et al., 2018) embedded into a long-term educational concept (i.e. university class setting. Improvements in movement technique performance that are highlighted in the instructional videos are most noticeable when extra instructions to encourage self-studying are provided.

Conclusions

We utilize a skilled system to create an interactive sport teaching E-Learning structure based on the E-Learning platform and network teaching. The suggested technique introduces a new teaching paradigm as well as a novel learning point. Knowing the research findings that have been described above, it is concluded that the video media based on e-learning volleyball.com is appropriate to be used as a volleyball service-learning medium for students. Beside that, when Indonesia enforces social distance regulation and physical distance regulation caused by Covid-19 Pandemic, the utilization of media like this is extremely suitable to be used in long distance learning.

Conflict of interest

The authors state no conflict of interest.

References

Vute, R. (2009). Teaching and coaching volleyball for the disabled. *Volleyball Technical Journal, 15*(1).

Chang, H. (2008). Implementation of a network sport training platform in E-Learning Information System. *WSEAS Transactions on Information Science and Applications, 5*(5), 756-765.

Fathoni, A. F. (2018). The Role of Blended Learning on Cognitive Step in Education of Sport Teaching by Adjusting the Learning Style of the Students. *The 4th International Seminar on Public Health Education (ISPHE 2018)-Atlantis Press., 12*(Isphe), 208-213. https://doi.org/10.2991/isphe-18.2018.49

Pardilla, H., Henjilito, R., Asilestari, P., & Husnayadi, I. (2020). Decreased Athlete Motor Skills: Before and After Activity Coronavirus Disease (Covid-19) Pandemic. *INSPIREE: Indonesian Sport Innovation Review, 1*(2), 57-65. https://doi.org/10.53905/inspiree.v1i2.6

Denysova, L., Shynkaruk, O., & Usychenko, V. (2018). Cloud technologies in distance learning of specialists in physical culture and sports. *Journal of Physical Education and Sport, 18*(1), 469-472. https://doi.org/10.7752/jpes.2018.s166

Invernizzi, P. L., Crotti, M., Bosio, A., Cavaggioni, L., Alberti, G., & Scurati, R. (2019). Multi-teaching styles approach and active reflection: Effectiveness in improving fitness level, motor competence, enjoyment, amount of physical activity, and effects on the perception of physical education lessons in primary school children. *Sustainability (Switzerland), 11*(2). https://doi.org/10.3390/su11020405

Ahmadi, N. (2008). *Panduan Olahraga Bolavoli.* Era Pustaka.

Beutelstahl, D. (2016). *Belajar Bermain Bola Voli.* Pionir Jaya.

Barbara L. Viera, Bonnie Jill Ferguson, M. (2000). *Bolavoli Tingkat Pemula.* PT. Rja Grafindo Persada.

Kumar, G., Shukla, A., Chhoker, A., & Thapa, R. (2021). Identification of Factors Determining Winning in Men's and Women's Beach Volleyball: a Logistical Regression Approach. *Teorìâ ta Metodika Fìzičnogo Vihovannâ, 21*(1), 26-35. https://doi.org/10.17309/tmfv.2021.1.04

Aip Syarifuddin dan Muhadi (1992). *Pendidikan Jasmani dan Kesehatan.* Departemen Pendidikan dan Kebudayaan. Indonesia.

Nuril Ahmadi (2007). *Panduan Olahraga Bola Voli.* Nuril Ahmadi.

Lopez-Martinez, A. B., & Palao, J. M. (2009). Effect of serve execution on serve efficacy in men's and women's beach volleyball. *International Journal of Applied Sports Sciences, 21*(1), 1-16.

Gabbett, T., Georgieff, B., Anderson, S., Cotton, B., Savovic, D., & Nicholson, L. (2006). Changes in skill and physical fitness following training in talent-identified volleyball players. *Journal of Strength and Conditioning Research, 20*(1), 29-35. https://doi.org/10.1519/R-16814.1

Alwan, S. A. (2021). Role of the Mindfulness in Reducing the Emotional Sensitivity among Young Volleyball Players. *Psychology and Education, 58*(2), 8083-8088. http://www.psychologyandeducation.net/pae/index.php/pae/article/view/3423/3057

Arsyad, A. (2004). *Media Pembelajaran.* Raja Grafindo Persada, Jakarta.

Gagné, R. M. (2012). The learning of principles. *In Readings in Educational Psychology: Learning and Teaching,* 66, 67-84.

Mares, M.-L., & Pan, Z. (2013). Effects of Sesame Street: A meta-analysis of children's learning in 15 countries. Journal of Applied Developmental Psychology. *Journal of Applied Developmental Psychology, 34*(3), 141-151. https://doi.org/10.1016/j.appdev.2013.01.001

Hamalik, O. (1982). *Media Pendidikan.* Bandung: Cipta Aditya Bakti.

Agus, S. Suryobroto (2001). *Diktat Teknologi Pembelajaran Pendidikan Jasmani.* Yogyakarta. FIK UNY.

Kirkorian, H. L., & Anderson, D. R. (2008). *Learning from educational media.* Blackwell Publishing. https://doi.org10.1016/j.appdev.2016.11.007

Azis, Y. M., Suharyati, H., & Susanti, S. (2019). Student's Experience of E-Learning, Learning Process and Perceived Learning Outcomes in Economic Math Course. *Journal of Humanities and Social Studies, 3*(2), 67-71. https://doi.org/10.33751/jhss.v3i2.1458

Abou El-Seoud, M. S., Taj-Eddin, I. A. T. F., Seddiek, N., El-Khouly, M. M., & Nosseir, A. (2014). E-Learning and Students' Motivation: A Research Study on the Effect of E-Learning on Higher Education. *International Journal of Emerging Technologies in Learning (IJET),* 9(4), 20. https://doi.org/10.3991/ijet.v9i4.3465

Samsuddin Siregar (2020). Efektivitas Model Pembelajaran Berbasis Permainan Dalam Meningkatkan Keterampilan Forehanddrivemahasiswa. *Jurnal Ilmu Keolahragaan, 19*(1), 54-62. https://doi.org/10.24114/jik.v19i1.18455

Sukendro, S., Habibi, A., Khaeruddin, K., Indrayana, B., Syahruddin, S., Makadada, F. A., & Hakim, H. (2020). Using an extended Technology Acceptance Model to understand students' use of e-learning during Covid-19: Indonesian sport science education context. *Heliyon, 6*(11), e05410. https://doi.org/10.1016/j.heliyon.2020.e05410

Palao, J. M. (2012). The impact of video technology on student performance in physical education. *Technology, Pedagogy and Education, 24*(1), 51-63. https://doi.org/10.1080/1475939X.2013.813404

Fukkink, R. G., Trienekens, N., & Kramer, L. J. C. (2011). Video Feedback in Education and Training: Putting Learning in the Picture. *Educational Psychology Review, 23*(1), 45-63. https://doi.org/10.1007/s10648-010-9144-5

El-Ariss, B., Zaneldin, E., & Ahmed, W. (2021). Using videos in blended e-learning for a structural steel design course. *Education Sciences, 11*(6). https://doi.org/10.3390/educsci11060290

Trakru, M., & Jha, T. K. (2019). E-Learning Effectiveness in Higher Education E-Learning Effectiveness in Higher Education. *International Research Journal of Engineering and Technology (IRJET), 06*(05), 96-101. https://www.irjet.net/archives/V6/i5/IRJET-V6I520.pdf

Noesgaard, S. S., & Ørngreen, R. (2015). The effectiveness of e-learning: An explorative and integrative review of the definitions, methodologies and factors that promote e-Learning effectiveness. *Electronic Journal of E-Learning, 13*(4), 278-290.

Hee Jun Choi (2005). The Effect of Context-Based Video Instruction on Learning and Motivation in Online Courses. *American Journal of Distance Education, 19*(4). https://doi.org/10.1207/s15389286ajde1904_3

Hornbæk, M., Hellevik, J., Schaarup, C., & Hejlesen, M. O. (2018). Usability of Eye Tracking for Studying the Benefits of E-learning Tutorials on Safe Moving and Handling Techniques. *The 16th Scandinavian Conference on Health Informatics,* 56-61.

Rovai, A. P., Ponton, M. K., Wighting, M. J., & Baker, J. D. (2007). A Comparative Analysis of Student Motivation in Traditional Classroom and E-Learning Courses. *International Journal on ELearning, 6*(3), 413-432.

Lee, M. C. (2010). Explaining and predicting users' continuance intention toward e-learning: An extension of the expectation-confirmation model. *Computers and Education, 54*(2), 506-516. https://doi.org/10.1016/j.compedu.2009.09.002

Born, P., Nguyen, N. P., Grambow, R., Meffert, D., & Vogt, T. (2018). Embedding tennis-specific teaching videos into long-term educational concepts to improve movement learning and technique performances. *Journal of Physical Education and Sport, 18*(1), 255-261. https://doi.org/10.7752/jpes.2018.01034

ЕФЕКТИВНІСТЬ ЕЛЕКТРОННОГО ВІДЕО ЗАСОБУ З НАВЧАННЯ ПОДАЧІ У ВОЛЕЙБОЛІ ДЛЯ СТУДЕНТІВ ФАКУЛЬТЕТУ СПОРТИВНИХ НАУК ДЕРЖАВНОГО УНІВЕРСИТЕТУ У МЕДАНІ, ЯКІ ПОСТРАЖДАЛИ ВІД COVID-19

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 5 с., 3 табл., 4 рис., 35 джерел.

Мета дослідження. Відомо, що система онлайн-навчання, медійні засоби та ресурси, які використовуються викладачами для досягнення навчальних цілей у волейболі, не є оптимальними. Дане дослідження було спрямоване на розробку електронного навчального відео засобу, який може бути використаний студентами як навчальний ресурс для оволодіння матеріалом з верхньої подачі, подачі у стрибку та плаваючої подачі у волейболі.

Матеріали і методи. Досліджуваними були студенти, яких розділили на експериментальну та контрольну групи, кожна група складалася з 40 осіб. У дослідженні застосовано експериментальний метод із планом тестування «до-після» (план попереднього та підсумкового тестування однієї групи). Рейтинговий тест – це інструмент, який було використано для оцінки ефективності відео засобу у вдосконаленні навичок подачі у студентів.

Результати. Результати дослідження та аналіз даних показали, що за допомогою електронного навчального відео засобу навички подачі (верхня подача, подача у стрибку та плаваюча подача) в експериментальній групі стали краще, ніж у контрольній групі, у якій не використовувалося електронне навчання.

Висновки. В експериментальній групі навички подачі покращилися порівняно з контрольною групою. Під час пандемії Covid-19 викладачам рекомендується використовувати електронні навчальні відео засоби у викладанні матеріалу з подачі у волейболі.

Ключові слова: медійне електронне навчання, подача у волейболі.

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ORIGINAL SCIENTIFIC ARTICLE

METHODOLOGY FOR DETERMINING THE SPEED-POWER CAPABILITIES OF BASKETBALL PLAYERS

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

The study objective is to develop a methodology for determining the jump height and jumping endurance in basketball players of various gaming functions using modern nanotechnology and microprocessor systems, in particular smartphones, personal computers, etc.

Materials and methods. The study used a method for determining jump height and jumping endurance using capacitive sensor devices based on a combination of modern nanotechnology and microprocessor systems, in particular smartphones, personal computers.

Results. The study showed that the use of modern nanotechnology to monitor the jump height and jumping endurance allows you to study these indicators with high accuracy, which is very important in scientific research. The study showed that the absolute height of the jump in center players is 328.1 ± 7.88 cm, in attackers – 324.1 ± 6.62 cm, in defenders – 314.4 ± 8.65 cm. The relative height of the jump in defenders is 57.7 ± 6.86 cm, which is on average 8.2 cm more than in center players, and 5.3 cm more than in attackers ($p < 0.001$ and $p < 0.02$, respectively).

Conclusions. The use of modern nanotechnology and microprocessor systems to determine the parameters of jump height and jumping endurance allows you to determine these parameters with high accuracy. The use of modern, accurate nanotechnology measurement and calculation of jump height and jumping endurance indicators using graphic data analysis provided a complete description and degree of development of various "jumping" qualities of basketball players.

Studies have shown that the jump height and jumping endurance in basketball players of different roles (defenders, attackers and center) differ with a high degree of reliability.

Keywords: basketball, jumping, jumping endurance, nanotechnology.

Introduction

The physical training of basketball players in modern basketball is of particular importance due to the expansion of the range of game actions, an increase in the load during the game, which requires from basketball players maximum muscle effort in rapidly changing situations (Koryahin, 2018; Kozina, Iermakov, Cretu, Kadutskaya, & Sobyanin, 2017; Demcenco, 2017).

In order to effectively and constantly increase the physical capabilities of basketball players and, in particular, jumping height and jumping endurance, you need to know following: what requirements for certain physical qualities are imposed by the game itself, how big are these requirements, what are the physical capabilities of athletes, what means and methods are most effective (Kondrashin, & Koryahin,1978; Fort-Vanmeerhaeghe, Montalvo, Latinjak, & Unnithan, 2016; Koryahin, 1994). It is necessary to have scientifically based tests to determine the jumping height and jumping endurance. Particular attention should be paid to ensure that the tests are scientifically substantiated and meet the requirements of test theory (Godik, 1980; Koryahin,1998). In mod-

ern basketball, players of different roles are subject to equally high demands on their physical fitness and, in particular, jumping ability (Anastasiadis, 2006; Asadi, Saez de Villarreal, & Arazi, 2015). Basketball players do a lot of "jumping" during the game in defense, and especially when fighting for the ball bounces off the ring. Without a sufficient level of development of jumping abilities and jumping endurance, it is very difficult to fight on the "shield" (Ferreira, Volossovitch, & Sampaio, 2014). Without a sufficient level of development of this quality, fatigue quickly occurs, the basketball player is not able to effectively throw to the basket, fight on the shield for the bounce off ball, counteract the throws into the basket by the opponent's players, etc (Cormery, 2008; Narazaki, Berg, Stergiou, & Chen, 2009; Montgomery, Pyne, & Minahan, 2010).

The study objective is to develop a methodology for determining the jump height and jumping endurance in basketball players of various gaming functions using modern nanotechnology and microprocessor systems, in particular smartphones, personal computers, etc.

Materials and methods

Study participants and study organization

89 highly skilled basketball players took part in the research.

Capacitive sensor devices based on the combination of modern nanotechnology and microprocessor systems such as smartphones, tablet computers and others were used to create a means of controlling jumping height parameters. The basis of these devices are electronic measuring systems of the athlete's spatial position based on capacitive sensors (Golyaka, Melnyk, & Helzhynsky, 2004; Gotra, Golyaka, & Helzhynsky 2008). Among the main advantages of modern sensor devices, we can mention versatility, high conversion accuracy, thermal stabilization, ease of use, minimal power consumption with the possibility of functioning with low-voltage power supplies (Gotra, Golyaka, & Helzhynsky 2008).

To control the height of the jump, a one-dimensional matrix of active band electrodes that are glued to the display wall were formed. Active electrodes will be connected to the signal converter by a signal line (electric cables harness).

In addition to the electrodes, the developed device includes following: a signal line, a signal converter, an interface, a communication line and a mobile communication system, in particular a smartphone or personal computer. In the system of measurement of jumping parameters, the matrix of electrodes forms a set of signals, by which it is possible to determine the highest and lowest point of the body of the object of control, his grouping and dynamics of movement with a time resolution of 0.01 s. Electrodes in the form of flexible conductive tapes are glued to the display wall up to 3 m high. The width of the tapes and the distance between them is 5 mm, which determines the resolution of measuring the spatial position of the object of control, in particular over the floor level.

Quantitative assessment of the basketball player's jumping endurance can be obtained by ergometric analysis, which allows obtaining a number of indicators that characterize the manifestation of jumping endurance:

1. Maximum jump height.
2. Number of jumps made with maximum height.

Calculation of these indicators is based on the method of graphic analysis. Fig. 1 illustrates the technique and sequence of calculation operations:

1. In logarithms, the jump height indicators of all serial jumps opposite their ordinal value are postponed.

2. At the points of the highest jumps, an average line (AB), which is parallel to the abscissa axis, is made. At the point of intersection of this line with the vertical axis, the jump height (point A) is determined.

3. At points where a decrease in jump height is clearly visible, the middleline (BC) is drawn. The rate of decrease in jump height as a result of fatigue is defined as tg < α.

Determining these three indicators (the maximum jump height, the number of jumps with the maximum jump height and the rate of decrease in jump height because of fatigue) is very important. They characterize the level of development of various qualities of basketball players. The maximum jump height, for example, is determined mainly by the power of the alactate anaerobic process, and the jump endurance (the number of jumps with the maximum jump height) is determined by the capacity of the alactate anaerobic process. It is possible having a good "jumping", but being bad in maintaining the jump height in serial jumps and vice versa. The interdependence between these indicators is neutral (r = 0.573). This shows that the level of development of one of these qualities does not depend on the other.

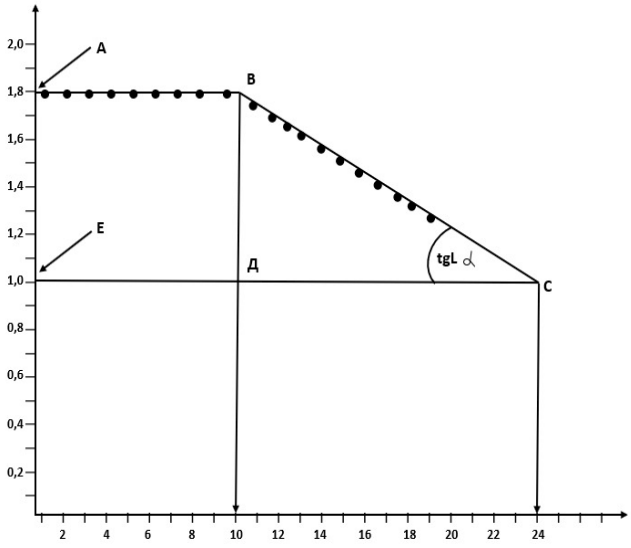

Fig. 1. Diagram for calculating jump height and jumping endurance in basketball players

Statistical analysis

To maintain a laboratory journal, to perform operations for storing the obtained research results and sorting them, and for calculating statistical data, the MS Excel program was used. The choice of methods of mathematical statistics was adequate to the purpose and objectives of our study and included the use of the following methods: the arithmetic mean according to the initial data, the error of the average value and the reliability of the difference between the data obtained.

Table 1. The results of the study of the jump height in highly qualified basketball players

Indicators / Game functions	Height with outstretched arm standing on tiptoes M ± SD	Jump height, cm	
		Absolute M ± SD	Relative M ± SD
Center (n = 27)	279.6 ± 6.1	328.1 ± 7.88	49.5 ± 5.59
Attackers (n = 15)	271.0 ± 6.33	324.1 ± 6.62	52.4 ± 3.74
Defenders (n = 27)	256.9 ± 5.85	314.4 ± 8.65	57.7 ± 6.86
Reliability of difference			
C - A	$p < 0.001$	$p < 0.05$	$p < 0.05$
C - D	$p < 0.001$	$p < 0.001$	$p < 0.001$
A - D	$p < 0.001$	$p < 0.001$	$p > 0.02$

Results

The results of the studies of the jump height in highly qualified basketball players (masters of sports) are presented in table.1. The table shows that the height with an outstretched hand up, standing on tiptoes, in high-class basketball players is: in the center players – 279.6 ± 6.1 cm, in attackers – 271 ± 6.33 cm, in defenders – 256.9 ± 5.85 cm.

The absolute height of the jump is: in the center – 328.1 ± 7.88 cm, in attackers – 324.1 ± 6.62 cm, in defenders – 314.4 ± 8.65 cm. The difference in these indicators is natural because players of different roles have different height. As for the relative height of the jump, the center players recorded not very high rates, as well as the attackers, which indicates a significant reserve to increase in their jump as can be seen from the table, defenders have a jump height of 57.7 ± 6.86 cm, which is on average 8.2 cm more than in center players, and 5.3 cm more than in attackers ($p < 0.001$ and $p < 0.02$, respectively).

When determining jumping endurance, it is best to perform jumps to a height of 90% of the maximum, until complete fatigue and refusal to continue working. When performing a series of jumps, the interval between it should be 3c. This time is enough for the basketball player to take a comfortable position and effectively perform the next jump – the interval of 3c is best set with the help of a metronome signal.

Our correlation analysis between height indicators and indicators in the jump height in highly qualified basketball players showed that there is a dependence between these indicators, but negative ($r = -0.555$). Differences that are restrained in our studies can be explained by the different ages of basketball players and their qualifications, as well as what we determined between jump height and height with an elongated arm upwards, standing on the toes, and not just growth. The differences that are obtained in our research can be explained by the different ages of basketball players and by differences in their qualifications, as well as the fact that we determined relation between the jump height and height with an outstretched up arm, standing on tiptoes, not just height. The relation between these indicators is presented in Fig. 2.

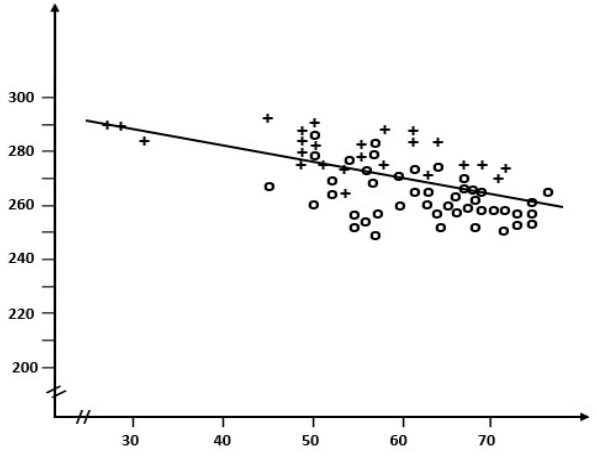

Fig.2. Dependence between relative jump height and height indicators with an outstretched upwards arm in highly qualified basketball players. On the ordinate axis - height, standing on tiptoes with outstretched upwards arm, cm. On the axis of the abscissa - the relative jump height, cm. Marks + - center, *- attackers, o-defenders

Discussion

The question of the importance of determining the jump height and jumping endurance was considered by many scientists and basketball coaches (Gomelsky, 1972; Poplavsky, 2004; Sushko & Mustafa, 2015) and others.

The results of our research are consistent with a number of scientific developments (Boichuk, Iermakov, & Nosko, 2017; Gonzalo-Skok, Sánchez-Sabaté, Izquierdo-Lupón, & Sáez de Villarreal, 2019; Iedynak, Galamandjuk, Kyselytsia, Nakonechnyi, Hakman, & Chopik, 2017) on the feasibility of improving the system of control over the state of physical, technical, tactical and psychological training of athletes.

These results of studies have shown that the use of modern nanotechnology for monitoring the jump height and jumping endurance allows you to determine these indicators with high accuracy, which is very important not only in scientific research, but also in the practical work of trainers. This makes it possible to develop training programs for basketball players, taking into account objective indicators of the state of their jump height and jumping endurance, which coincides with the results of the conclusions of a number of other researchers (Khudolii, 2019; Raiola, Altavilla, Tafuri, & Lipoma, 2016; Tyshchenko, Hnatchuk, Pasichnyk, Bubela, Semeryak, 2018).

The results of the study complement information on the control of such important qualities for basketball players as jump height and jumping endurance, and make it possible to do this with high accuracy (Demcenco, 2017; Poplavsky, 2004; Tyshchenko, Hnatchuk, Pasichnyk, Bubela, Semeryak,

2018). In further studies, this technique has a great perspective in the examination of basketball players of different age groups, athletes of different qualifications. The proposed method of determining the jump height and jumping endurance will have great importance for scientific research.

Conclusions

1. The use of modern nanotechnology and microprocessor systems to determine the parameters of jump height and jumping endurance allow to determine these parameters with high accuracy.

2. Studies have shown that the indicators of jump height and jumping endurance in defenders, attackers and center differ with a high degree of difference, which indicates the need for an individual approach to basketball players of different game ampoule in the preparation of training programs.

2. The use of modern, accurate nanotechnology and calculation of jump height and jumping endurance indicators using graphic analysis give a complete characteristic, the degree of development of various "jumping" qualities of basketball players.

Conflict of interest

The authors declare no conflict of interest.

References

Koryahin, V. (2018). Effectiveness of basketball players training process. *Journal of Physical Education and Sport, 16*(2), 163, 1029-1030.

Kozina, Z., Iermakov, S., Cretu, M., Kadutskaya, L., & Sobyanin, F. (2017). Physiological and subjective indicators of reaction to physical load of female basketball players with different game roles. *Journal of Physical Education and Sport, 17*(1), 56, 378-382. https://doi.org/10.7752/jpes.2017.01056

Demcenco, F. (2017). Development of applicative coordination abilities of 12-13 years old pupils through basketball elements. *Journal of Physical Education and Sport, 17*(2), 79, 527-532.

Kondrashin, V., & Koryahin, V. (1978). *Training of the basketball players of high grade.* Kyiv: Publishing house "Zdorov'ya", 93.

Fort-Vanmeerhaeghe, A., Montalvo, A., Latinjak, A., & Unnithan, V. (2016). Physical characteristics of elite adolescent female basketball players and their relationship to match performance. *Journal of Human Kinetics,* 53, 167-178. https://doi.org/10.1515/hukin-2016-0020

Koryahin, V. (1994). *The structure and content of modern training of basketball players: Dissertation by the Doctor of Pedagogical Sciences.* Moscow (in Russian)

Godik, M.A. (1980). *Control of training and competitive loads.* Physical Education and Sports. Moscow

Koryahin, V. (1998). *Training of the highly skilled basketball players. Textbook for the correct physical education.* Lviv: Publishing house «Krai», 192.

Anastasiadis, M. (2006). *The basketball training.* Athens: IN. Elvekalt EPE.

Asadi, A., Saez de Villarreal, E., & Arazi, H. (2015). The effects of plyometric type neuromuscular training on postural control performance of male team basketball players. *Journal of Strength and Conditioning Research, 29*(7), 1870-1875. https://doi.org/10.1519/jsc.0000000000000832

Ferreira, A. P., Volossovitch, A., & Sampaio, J. (2014). Towards the game critical moments in basketball: A grounded theory approach. *International Journal of Performance Analysis in Sport, 14*(2), 428-442. https://doi.org/10.1080/24748668.2014.11868732

Cormery, V. (2008). Rule change incidence on physiological characteristics of elite basketball players: a 10-year-period investigation. *British Journal of Sports Medicine, 42*(1), 25-30. https://dx.doi.org/10.1136/bjsm.2006.033316

Montgomery, P. G., Pyne, D. B., & Minahan, C. L. (2010). The physical and physiological demands of basketball training and competition. *International Journal of Sports Physiology and Performance,* 5, 75-86. https://doi.org/10.1123/ijspp.5.1.75

Narazaki, K., Berg, K., Stergiou, N., & Chen, B. (2009). Physiological demands of competitive basketball. *Scand J Med Sci Sports, 19*(3), 425-432. https://doi.org/10.1111/j.1600-0838.2008.00789.x

Golyaka, R., Melnyk, O., & Helzhynskyi, I. (2004). Compensation of parasitic influence of signal transmission line in microelectronic sensors of volume type. *Bulletin of the National University "Lviv Polytechnic". Elements of the theory and devices of solid-state electronics,* 512, 71-78.

Gotra, Z., Golyaka, R., & Helzhinsky, I. (2008). Research and improvement of stability of performance of operational amplifiers in capacitive sensors driver circuits. *Technology and design in electronic equipment, 3*(75), 20-24.

Gomelsky, E. (1972). Under both shields. *Journal "Sports games",* 3.

Poplavsky, L. Y. (2004). *Basketball.* Kyiv: Publishing House "Olympic literature", 446. (in Russian)

Sushko, R., & Mustafa, A. (2015). *Evaluation of technical and tactical activities of basketball players with taking into account the differences of the periods of play activity.* Kyiv: Publishing house "Olympic literature", 177.

Boichuk, R., Iermakov, S., & Nosko, M. (2017). Pedagogical conditions of motor training of junior volleyball players during the initial stage. *Journal of Physical Education and Sport, 17*(1), 327-334. https://doi.org/10.7752/jpes.2017.01048

Gonzalo-Skok, O., Sánchez-Sabaté, J., Izquierdo-Lupón, L., & Sáez de Villarreal, E. (2019). Influence of force-vector and force application plyometric training in young elite basketball players. *European Journal of Sport Science, 19*(3), 305-314. https://doi.org/10.1080/17461391.2018.1502357

Iedynak, G., Galamandjuk, L., Kyselytsia, O., Nakonechnyi, I., Hakman, A., & Chopik, O. (2017). Special aspects of changes in physical indicators of young men with different somatotypes between 15 and 17 years of age. *Journal of Physical Education and Sport, 17*(4), 79, 2690-2696.

Khudolii, O. (2019). Research program: modeling of young gymnasts' training process. *Teorìâ ta Metodika Fìzičnogo Vihovannâ, 19*(4), 168-178. https://doi.org/10.17309/tmfv.2019.4.02

Raiola, G., Altavilla, G., Tafuri, D., & Lipoma, M. (2016). Analysis of learning a basketball shot. *Journal of*

Physical Education and Sport, 16(1), 1, 3-7. https://doi.org/10.7752/jpes.2016.01001

Tyshchenko, V., Hnatchuk, Y., Pasichnyk, V., Bubela, O. O., & Semeryak, Z. (2018). Factor analysis of indicators of physical and functional preparation of basketball players. *Journal of physical education and sport, 18*(4), 269, 1839-1844. https://doi.org/10.7752/jpes.2018.s4269

МЕТОДИКА ВИЗНАЧЕННЯ ШВИДКІСНО-СИЛОВИХ МОЖЛИВОСТЕЙ БАСКЕТБОЛІСТІВ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 5 с., 1 табл., 2 рис., 25 джерел.

Мета дослідження – розробити методику визначення висоти стрибка та стрибкової витривалості у баскетболістів різних ігрових функцій з використанням сучасних нанотехнологій та мікропроцесорних систем, зокрема смартфонів, персональних комп'ютерів тощо. Розробити рекомендації, які спрямовані на підвищення ефективності тренувань висоти стрибка і стрибкової витривалості.

Матеріали та методи. У дослідженні був використаний метод визначення висоти стрибка і стрибкової витривалості з використанням ємнісних сенсорних пристроїв, які ґрунтуються на поєднанні сучасних нанотехнологій та мікропроцесорних систем, зокрема смартфонів, персональних комп'ютерів. Основою цих пристроїв є електронні вимірювальні системи просторового положення спортсмена на базі ємнісних сенсорів.

Результати. Проведене дослідження показало, що використання сучасних нанотехнологій для моніторингу висоти стрибка і стрибкової витривалості дозволяють з високою точністю дослідити ці показники, що є дуже важливим при проведенні наукових досліджень.

Дослідження показало, що абсолютна висота стрибка у центрових становить 329,1 ± 2,31 см, у нападників – 324,1 ± 3,65 см, у захисників – 314,4 ± 3,42 см. Відносна висота стрибка у захисників становить 57,7 ± 2,71 см, що в середньому на 8,2 см більше, ніж у центрових, та на 5.3 см більше, ніж у нападників ($p \geq 0,999$ та $p \geq 0,98$ відповідно). Цей факт, безумовно, необхідно враховувати при плануванні тренувального процесу гравців різного амплуа.

Висновки. Використання сучасних нанотехнологій та мікропроцесорних систем для визначення параметрів висоти стрибка і стрибкової витривалості дозволяють з високою точністю визначити ці параметри. Використання сучасних, точних нанотехнологій вимірювання і розрахунок показників висоти стрибка та стрибкової витривалості за допомогою графічного аналізу даних надає повну характеристику і ступінь розвитку різних «стрибкових» якостей баскетболістів.

Представлена в роботі методика визначення таких важливих показників, які характеризують ступінь розвитку різних якостей баскетболістів, таких як максимальна висота стрибка, кількість стрибків з максимальною висотою, а також можливість визначення швидкості зниження висоти стрибка в результаті втоми.

Дослідження показали, що показники висоти стрибка і стрибкової витривалості в баскетболістів різного амплуа (захисників, нападаючих і центрових) різняться з високим ступенем достовірності.

Ключові слова: баскетбол, стрибучість, стрибкова витривалість, нанотехнології.

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ORIGINAL SCIENTIFIC ARTICLE

THE EFFECT OF COMPREHENSIVE TEACHING LEARNING-BASED TRAINING ON SOCIAL SKILLS AND ATTITUDES

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Abstract

The study purpose was to determine the effect of a comprehensive teaching learning-based training model on the skills and social attitudes of young football players.

Materials and methods. This is an experimental study with a sample of 36 male football athletes aged 10-12 years. Samples are players who registered and trained at the Real Madrid Foundation Yogyakarta football school. Samples attended training with a frequency of 3x week with a minimum attendance of 80% in 20 weeks and were selected to participate in district or provincial football competitions. The instrument used for measuring football technical skills was the David Lee test, and for social attitudes the Prosocial and Antisocial Behavior Sport Scale (PABSS) questionnaire was used. The data analysis technique was the paired sample t-test.

Results. The results showed that the comprehensive teaching learning-based training model affected the skills and social attitudes of young football players. In the 10 year age group, there was an influence on skills of 1.497 and social behavior of 2.750, which means that it is influential. In the 11 year age group, it was found that the effect on skills was 0.506 and social behavior was -2.812, which means that there was no effect on social behavior. In the 12 year age group, it was found that the effect on skills was 0.19 and social behavior was 1.148, which meant that it affected.

Conclusions. Young football coaches can make a comprehensive teaching learning-based training model as a choice of strategies in the development of performance skills and personality.

Keywords: football, skills, social attitudes, youth.

Introduction

As is well known, the benefits of doing sports training are numerous. Them sports training can increase knowledge, skills, and attitudes so that an individual can achieve optimal performance. The exercise program can be adjusted to various age categories, including children, youth, adults, parents, and the elderly. Training at a young age has the main objective of increasing competence and skills in a sport (Bjørndal & Ronglan, 2021; Schroepf & Lames, 2018). In addition, it is hoped that sports training can support the development of personality (Kavussanu & Spray, 2006), character (Gilbert et al., 2001; Harwood, 2008), and increase the degree of health (Henry, 2013). By achieving sports goals at a young age, it is hoped that it can support optimal performance. Both in academic and non-academic aspects. Another goal that can be achieved in sports training is an increase in optimal performance in competitions and positive personality development that can arise from the training process for young athletes, but in practice, it is not as easy as it is known. Among them, various problems are encountered related to the interaction of coaching and training to achieve comprehensive physical performance, technical skills, behavior, or attitudes experienced by young athletes which cannot be avoided (Wei et al., 2016) including in the soccer branch.

Problems that occur among young soccer athletes include the process of coaching young athletes who are less attentive and only concerned with results. This can happen

if the approach taken by the coaches or coaches to their athletes is like the approach between an employer and a helper that is not familial. As a result, communication that arises between coaches and athletes is not established comfortably and familiarly. This is in line with the statement put forward by the Ekstrand et al. (2019) that the communication process that coaches and young soccer athletes need to carry out is primary and secondary communication. Primary communication can be carried out by the trainer orally using informal language and style. The language used is presented simply and adapted to character of young athletes. In addition to using spoken language, to express the message to be conveyed, coach also uses gestures to being able to better express motivational messages to athletes. Secondary communication that can be done by coaches to young soccer athletes is via video, telephone, or group chats (Lawrason et al., 2019). The problems and efforts made by this coach are carried out so that potential that exists in young football athletes can develop optimally.

In addition to communication problems between coaches and young soccer athletes that affect the teaching process and optimize the potential of young soccer athletes, problems regarding the physical abilities of each athlete also affect the process of optimizing the potential of these young soccer athletes. Young athletes generally have status as students in formal schools, and have loads of training and learning with various targets to achieve minimum competence (Goldberg & Chandler, 1995). Young athletes participate in training with a frequency of 3-5 times/week, or an average of 6-10 hours per week. With these training hours, young athletes are expected to experience progressive development in components of technical, physical, and character skills. but several research studies show other facts that young athletes experience stress (Pritchard & Wilson, 2005) due to fatigue, difficulty in managing lesson schedules due to competitions, and coach inflexibility factors (Wiese, 1988). This causes talented athletes to stop training (Cresswell & Eklund, 2007) athlete's behavior becomes aggressive (Gencheva, 2015), and athletes use doping (Bloodworth et al., 2012).

Young football athletes who are mostly elementary to high school students are prone to injury. This is because students who are still in elementary and middle school are still in a period of growth whose muscle and bone strength is still weak (Zhang et al., 2020). This is also consistent with the results of a study which showed that 53 elite soccer players aged between 15 and 18 years tended to experience 320 injuries and 82 illnesses occurring during soccer practice and competition (Brink et al., 2010). Furthermore, injuries that often occur in young soccer athletes are caused by physical stress. Physical stress that occurs in young soccer athletes is closely related to congenital diseases experienced by them (Zorzi et al., 2020). In addition, nearly 65 young male soccer players with an average age of 16.6 years experienced difficulties in practicing and optimizing physical abilities (Hermassi et al., 2020). In this case, interpersonal stress can also determine the optimization of the performance of young football athletes. The level of performance in optimizing the ability of young football athletes needs to be maintained effectively. This is because if the performance in optimizing the ability of young football athletes is low, negative feelings will arise in the social climate between coaches and young football athletes (Gerabinis & Goudas, 2019). Therefore, there is a need for monitoring from coaches and physiological staff in monitoring the condition and recovery of young soccer athletes.

In addition, negative perceptions about girls playing soccer are still inherent in society. As a result, the role of girls in soccer games is still minimal and their contribution to football has not been so effective than girls (Collins et al., 2021). This is what sometimes creates a stigma in society that football is not a sport for girls, but a sport for boys. Therefore, coaching and training models for young athletes include the following: 1) development model sport participation (DMSP) by Cote', 2) long term athlete development (LTAD) popularized by Balyi and Hamilton, 3) positive youth development (YPD) proposed by Smith and McGannon (2018) and an often-debated model of early specialization training. Futhermore, Strachan et al. (2016) stated that several training models have been developed, for example, TPSR, SUPER, Project SCORE where the training model is designed to be able to develop attitudes and behavior of athletes. The results of research on the DMSP model conducted in England show that adolescent athletes aged 13-15 years who carry out sports activities more than two sports can compete at the national level at the age of 16-18 years compared to those who do early specialization or pursue one sport (Bridge & Toms, 2013). Research related to deceptive and aggressive behavior in team sports is influenced by the moral atmosphere in the team where the motivation to achieve high performance is strongly associated with it (Farič et al., 2019).

The training model based on comprehensive teaching-learning is a training model implemented at the Real Madrid Foundation football school in Yogyakarta. The concept of daily training must contain 5 content and materials, namely social skill blocks, education, physical and movement skills, technical and tactical skills, and game rules blocks. The daily exercise design must contain a game with the contents of each game being able to accommodate a minimum of 3 blocks (Malina, 2010). Policies, sports training strategies at a young age to achieve optimal physical performance, techniques, tactics, and positive personality development have been carried out by several researchers with various considerations, but their effectiveness is still debated. This study aims to determine the effect of a comprehensive teaching learning-based training model on technical skills and social attitudes of young football players. This research hypothesizes that the training model based on comprehensive teaching-learning has a positive effect on the skills and social attitudes of young soccer players.

Materials and methods

General background

In this study, researchers used Quasi-Experimental Research in quantitative research methods with a 2×2 factorial research design. The 2×2 factorial research design is a research design by provides action on two variables that are manipulated simultaneously to study the effect of each variable on the dependent variable or the effect caused by the interaction between several variables (Boettcher et al., 2020). The 2×2 factorial research design has two factors with each factor having two levels. In addition, 2×2 factorial research

is the simplest factorial research design (Leifer et al., 2021). Furthermore, the 2×2 factorial research design used in this study consisted of two learning strategies, namely training, and training based on comprehensive learning. In addition, the other two factors are skills and social attitudes. The research type of quasi-experimental 2×2 factorial was chosen because it makes it easier for researchers to control research subject. The quasi-experiment was chosen because there was a balanced division of the group, as well as the absence of a specific control group so that results could be compared with a certainty (Fichera & von Hinke, 2020).

Study participants

Participants who took part in the treatment were students who took part in training at the Real Madrid Foundation football school in Yogyakarta. Participants consist of 3 age groups, namely 10, 11, and 12 years, which can simply be seen in Table 1.

Instruments and procedures

The instrument used to measure football technical skills using the David Lee test. The social attitude instrument uses the Prosocial and Antisocial Behavior Sport Scale (PABSS) questionnaire. The two test instruments were chosen because they were considered very suitable to be applied to the impact test research that was to be developed. In the implementation of the research, the experimental research sample was classified into three experimental groups based on the age group. At the initial stage, the research sample will be given a pretest related to the research. The sample follows the treatment in the form of training with a frequency of 3x/week with a minimum attendance of 80% in 20 weeks and is selected to participate in a football competition at the district, provincial level. Furthermore, after the research sample has completed all treatments, the researcher will perform a posttest to assess whether there is a significant increase in ability at the pretest and posttest. The measuring instrument used to measure football technical skills uses the David Lee test, to measure social attitudes using the Prosocial and Antisocial Behavior Sport Scale (PABSS) questionnaire. The data analysis technique used in this study was to use paired sample t-test. Table 2 following descriptions of experimental group are presented.

Based on Table 2, it can be seen that T0 is the test before treatment, T1 is the test after treatment, X1 is the treatment in the experimental group 1 (age 10 years), X2 is the treatment in the experimental group 2 (age 11 years), and X3 is the treatment in the group. experiment 3 (age 12 years). However, the David Lee test and questionnaire used in this study were first tested for validity and reliability by 6 expert validators with the aim of knowing its validity and reliability. After the David Lee test and questionnaire were tested for validity and reliability, then its validity was analyzed using Aiken'sV equation as equation 1.

$$V = \sum \frac{r - l_o}{[n(c-1)]} \quad (1)$$

where is the validity value, is the number given by the nth validator, is the lowest number of validity assessments, is the number of validators, and is the highest number of validity assessments. After the value of the coefficient V is obtained, then the value of the coefficient V is compared with the Aiken table. An item or questionnaire is said to be valid if the value of the Aiken validity coefficient is greater

Table 1. Participant data

No.	Name	Age	Gender
1.	AFA	10	Male
2.	AS	10	Male
3.	BPRN	10	Male
4.	CBA	10	Male
5.	EBB	10	Male
6.	FNR	10	Male
7.	FAR	10	Male
8.	GB	10	Male
9.	KAV	10	Male
10.	KAMS	10	Male
11.	Mar	10	Male
12.	MSR	10	Male
13.	SD	10	Male
14.	AD	11	Male
15.	AFP	11	Male
16.	AAS	11	Male
17.	AZ	11	Male
18.	BBB	11	Male
19.	DAP	11	Male
20.	DAF	11	Male
21.	EM	11	Male
22.	FZW	11	Male
24.	JKP	11	Male
25.	MKI	11	Male
26.	MNSS	11	Male
27.	MI	11	Male
28.	RRN	11	Male
29.	RC	11	Male
30.	SW	11	Male
31.	ZMZ	11	Male
32.	Abh	12	Male
33.	Arj	12	Male
34.	Dec	12	Male
35.	IM	12	Male
36.	Vit	12	Male

Table 2. Description of experiment group

Description of Experiment Group			
Group	**Pre-Test**	**Treatment**	**Post-Test**
10 years old	T0	X1	T1
11 years old	T0	X2	T1
12 years old	T0	X3	T1

than or equal to the minimum value listed in the Aiken table (Aiken et al., 1991).

Meanwhile, the reliability of the David Lee test and questionnaire used in this study were tested using the item separation index (item estimate) and the person separation index (case estimate) through the Quest program (Subali & Suyata, 2011). If the greater the value of the David Lee test and questionnaire item separation index, the greater the accuracy of the overall David Lee test and questionnaire item with the model used, namely PCM. In addition, the higher the person separation index value, the higher the consistency of each item in measuring the person's ability (Subali & Suyata, 2011). The criteria for item estimate and case estimate values can be shown in Table 3 (Sumintono & Widhiarso, 2015).

Table 3. Item value criteria and case estimate

Item Reliability Value and Case Estimate	Criteria
	Excellent
0.91-0.94	Very Good
0.81-0.90	Good
0.67-0.80	Moderate
	Weak

Statistical analysis

This research is an experimental study consisting of four groups with the same training model treatment, namely a training model based on comprehensive teaching-learning but different in load and intensity according to age groups. The treatment was carried out for 20 weeks. The number of samples is 36 young football athletes with all-male gender. The samples were players who were registered and trained at Real Madrid Foundation football school. Real Madrid Foundation football school provides training services in the city of Yogyakarta.

Results

Results of Instrument Validity and Reliability

The data on the feasibility of this measurement instrument includes data on the validity and reliability of the measurement instrument in the form of the David Lee test and questionnaire. The results of the first analysis of this measurement instrument are the results of the validity analysis of the David Lee test and the questionnaire which were analyzed using the Aiken's V equation as shown in equation 1. The results of the validity of the David Lee test and the questionnaire used in this study can be shown in Table 4 below.

There are 6 expert validators who validate the David Lee test and questionnaire each. Therefore, the error rate in the Aiken's V table used is 1% ($p < 0.01$) and the items in the David Lee test and questionnaire are said to be valid if the Aiken coefficient ($V \geq 0.89$) (Aiken & Stephen, 1985). Based on Table 4, it is obtained that the David Lee test and the questionnaire are both valid, because the Aiken validity value is greater than 0.89 ($V \geq 0.89$), which is 0.924. Based on the results of the validity, it can be stated that the David Lee test and questionnaire are valid and appropriate to be used to measure the variables in this study. After the David Lee test and questionnaire were analyzed for validity using the Aiken's V equation, the next step was to analyze the reliability. The results of this reliability are also used as a reference in determining the feasibility of the David Lee test and the questionnaire that has been developed by the researcher. The reliability results of the David Lee test and questionnaire can be presented in Table 5.

Table 4. Instrument validity results

Measurement Instrument	Number of Items	Aiken Validity Value	Information
David Lee test	10	0.913	Valid
Questionnaire	20	0.936	Valid
Instrument Validity Value		0.924	Valid

Based on Table 5, it can be observed that the reliability coefficient for the measurement instrument in the form of a questionnaire obtained the summary item of estimate and summary case of estimate values that are more than 0.7 which are included in the reliable category. Meanwhile, for the measurement instrument in the form of the David Lee test, the summary item of estimate and summary case of estimate values are more than 0.7 which are included in the reliable category. Meanwhile, the summary of item estimate and summary of case estimate values obtained in the David Lee test and questionnaire items indicate that the David Lee test items and the developed questionnaires are both included in good criteria. Furthermore, the David Lee test item and this questionnaire show the proper consistency of the choices of high school students. In other words, each item of the David Lee test and questionnaire shows the same score, when assessed by different high school students. Therefore, based on the validity and reliability data that have been obtained as shown in Table 4 and Table 5, it can be stated that measurement instrument developed is feasible to be used in this study.

The Effect of Comprehensive Learning Based Training Model on Social Skills and Attitudes

After conducting a series of studies, it can be seen the data regarding skills, social attitudes, and the results of the paired sample t-test of the experimental group aged 10 years.

Table 5. Instrument reliability results

Reliability	Reliability Coefficient		Category	
	David Lee Test	Questionnaire	David Lee Test	Questionnaire
Summary of item estimate	0.83	0.89	Reliable	Reliable
Summary of case estimate	0.85	0.87	Reliable	Reliable

Table 6. Results of playing skills and social attitudes

Aspects	Group	T0	T1	t	Sig. (2-tailed)
Playing Skills	10 years old	33.35 ± 3.69	31.03 ± 3.05	1.497	0.16
	11 years old	31.44 ± 3.91	30.89 ± 3.08	0.506	0.62
	12 years old	29.86 ± 3.65	29.42 ± 6.49	0.19	0.857
Social Behavior	10 years old	76.61± 4.48	80.08± 6.91	-2.750	0.018
	11 years old	81.24 ± 3.40	83.65 ± 5.59	-2.812	0.013
	12 years old	83.83 ± 3.87	86.00 ± 4.69	-1.148	0.303

The results of the measurement of basic playing skills, social attitudes, and the results of the paired sample t-test with the SPSS 21 experimental group aged 11 years. As well as skills, social attitudes and the results of the paired sample t-test experimental group aged 12 years. More detailed data can be seen in Table 6. Table 6 contains the results obtained regarding skills, social attitudes, and the results of the paired sample t-test experimental group aged 10 years in group 1 with 13 athletes as members.

The results in Table 6 show that the aspects of early playing skills meet the score of 33.35 ± 2.69, while the aspects of final playing skills are 31.03 ± 3.05. So that it is found that t is 1.497. Whereas in the early social aspects, the score was 76.61 ± 4.48, while the final social behavior aspect was 80.08 ± 6.91. So that it is found that t is 2,750. Table 6 contains the results obtained regarding skills, social attitudes, and the results of the paired sample t-test experimental group aged 11 years in group 1 with 17 athletes as members.

The results in Table 6 show that the aspects of early playing skills meet the score of 31.44 ± 3.91, while the spec for final playing skills is 30.89 ± 3.08. So, it is found that t is 0.506. Whereas in the early social aspects, the score was 81.24 ± 3.40, while the final social behavior aspect was 83.65 ± 5.59. So that it is found that t is -2,812. Meanwhile, Table 6 contains the results obtained regarding skills, social attitudes, and the results of the paired sample t-test experimental group aged 12 years in group 1 with 6 athletes as members. The results in Table 6 show that the aspect of early playing skills meets the score of 29.86 ± 3.65, while the spec of final playing skills is 29.42 ± 6.49. So that it is found that t is 0.19. Whereas in the aspect of the initial social behavior, the score was 83.83 ± 3.87, while the aspect of the final social behavior was 86.00 ± 4.69. So that it is found that t is 1.148.

Discussion

The training model based on comprehensive teaching-learning has an influence on the skills and social attitudes of young football players at SSB Realmadrid Foundation Yogyakarta. The development of an athlete for optimal appearance can be carried out using a variety of training methods and strategies. Discussions related to various methods, training strategies such as early specialization models, long-term athlete development, positive youth development are the dilemmas experienced by sports training practitioners to choose which one is the best. Early specialization models where the training process only focuses on one sport for young athletes are mostly carried out by Eastern European countries. Early specialization models are oriented and focus on the athlete's performance or performance, in some cases this training model succeeds in achieving achievement goals earlier but decreases more rapidly and in other cases results in athletes stop training (McGowan et al., 2020). Research by McGowan states that early specialization in one sport does not increase the chances of injury (De Pero et al., 2009). The early specialization training model is one of the policies or strategies for developing elite athletes with risk of injury and short sports careers. The coaches need innovative training models that are more comprehensive to accommodate all objectives as well as the correct stages of sports coaching.

The implementation of a 20-week comprehensive teaching learning-based training model has had a positive effect on skill development. Bellistri, et al, 2016 in their study found that the physical abilities and technical skills of the 12 Italian national team u-10 players are as follows: dribbling technical skills measured by the Shuttle Dribling Test were achieved with an average of 10.66 ± 0.57 seconds, when measured with the Slalom Dribbling Test it was achieved with a mean time of 22.34 ± SD 1.28 seconds (Ali, 2011). Post-treatment technical skills showed a progressive improvement in all experimental groups aged 10, 11, and 12 years. The limitation of the David Lee test measuring instrument is that it is only able to measure the technical skills of dribbling, under-passing, and over-passing but other skills in playing football have not been able to be measured. The ability to make decisions and the involvement of players in playing the game cannot be determined with the David Lee test measuring instrument. The appearance of individual performance of a football player as a whole is a combination of several abilities that are integrated in a complex way (Stolz & Pill, 2014). The individual player performance involves physical abilities, technical skills implemented to solve problems in play, decision making, and involvement in the game as a whole (Bloomfield et al., 2007). Physical abilities and technical skills greatly influence an individual's appearance.

The skills of passing and dribbling techniques have a strong relationship based on the analysis that individual action in a soccer match found that dribbling and passing skills at close range are the skills most often performed during playing matches (O'Reilly & Wong, 2012). Loughborough Soccer Passing Test (LSPT) and Loughborough Soccer Shooting Test (LSST) is football skills measurement tools developed to assess various aspects of Football skills in a dynamic context (Lloyd & Oliver, 2012). The task or motion instruction that must be performed from both tests can reveal perceptions and test the player to perform a holistic motion task that requires the optimal performance of the skill (Ryan & Deci, 2000). And both tests demonstrate and meet the validity or reliability requirements in assessing the performance of football skills. The appearance of a football player

will be more appropriate if it is observed when playing and several components of appearance are recorded comprehensively. Observations by analyzing video matches or games that a player is participating in may in future be more reliable than existing measuring instruments (Standage et al., 2005).

Improvement in skills occurred in all treatment groups but what is interesting is the very high difference in ability between the ages of 10, 11, and 12 years. The technical skills achieved by the 12-year-old group averaged 29.42 seconds, while the 10-11-year-old group averaged 20.97 seconds, so there is a difference of 40%. Anthropometric factors, physiology, and cognitive abilities that develop very rapidly at the age of 10-11 years are predicted to greatly affect the technical abilities of young players. The use of the same measuring instrument in this study to measure skills has advantages but also limitations. The advantage of using the same measuring instrument is that there is a significant difference in ability between the ages of 10-11 years and those under 12 years of age. Based on the results of this study, there are significant differences between the phases of children aged 10, 11, and 12 years. The results of this study are by the results of research (Kavussanu & Boardley, 2009) which states that there are significant differences between children and adolescents in terms of the development of mobility skills. The significant difference in movement skills between children and adolescents is the result of the study. Movement skills as measured by kicking motion if you pay attention to the results of the study (García-García et al., 2017), there is a significant increase in adolescent boys, which is 26%.

The results of this study indicate that the training model results in a continuous, enhancement that allows individuals, groups to develop at any age stage. The results of the study are by the philosophy of the youth positive development model where training allows individual athletes to experience physical performance and skill development. Physical ability and skills do not mean that the team is capable of achieving victory in a championship. Comprehensive development of individual young football players in this perspective sacrifices the success of short-term performance (victory) but can maximize the opportunity to foster a sense of well-being and provide long-term benefits (Camiré & Trudel, 2010). The practice philosophy based comprehensive teaching-learning will help children to appreciate the benefits of the training process and develop intrinsic motivation to stay in the training process (Camiré et al., 2013) and relate to positive behavior (MacDonald et al., 2010).

Sports training activities that are oriented towards winning at a competition event can cause stress to young athletes if the coach, the parents do not have the appropriate behavioral response in responding to the development of training, training results, and competition. The task of the coach, the parents, is to ensure that all components of the young athlete develop in a positive direction, not only in appearance when competing, but developing positive attitudes, behaviors, and character. Parents are generally anxious if their children, who are young athletes and students, experience negative attitudes towards their children. The social attitude in this study can be defined as someone who has empathy, task orientation, ego orientation (Fisher et al., 2019). The results showed that the training model based on comprehensive teaching-learning had a significant effect on social attitudes at the ages of 10 and 11, while at the age of 12 the training model had an effect but it was not significant. Several studies related to sports training activities on athlete behavior have disagreements, including stating that training activities and competitive sports competitions hurt athletes' behavior, but several studies have stated that training activities and sports competitions can be used to develop positive attitudes, behaviors, and personality development. The aggressive behavior of young football players is not easy to change, male soccer players are more aggressive than women, CC, soccer coaches must make efforts to reduce them by various strategies to change aggressive behavior.

Modified sports competitions can develop a fair play attitude in competition interactions or sports competitions. Most athletes claim that social behavior can be developed through sports activities and organized competition. Managers and coaches are expected to be proactive, involved, take the initiative to develop character in program planning to promote the development of attitudes, behavior, and morale of athletes (Gould et al., 2007). research in the forms of indirect teaching behavior (ITB) in physical education subjects that affect the social and moral development of students (Bodey et al., 2009). The coach is someone who has the most influence on the results that will be achieved by athletes in future. The organization of sports education and training services with the chosen coaching philosophy will influence the implementation and approach to training process that is applied. Athletes will behave negatively if the coach who is supposed to be a role model is unable to carry out his role. Trainers who have attended formal education or courses have a better effect on personality and social attitudes of athletes than coaches with non-formal education (Cappelen et al., 2020). The heuristic vision was developed to help train coaches to better relate, have awareness, and care (Weller et al., 2018), three things that help and become capital in improving and developing athletes in a holistic manner.

Philosophy winning is the second athlete the first chosen in the training model based on comprehensive teaching-learning has a deep meaning, namely at the stages of young players, athlete development is more important than victory. Specialization is not recommended with a comprehensive teaching learning-based training model, by not prioritizing victory, the athlete's stress level is lower, and negative, antisocial behaviors in competition can be avoided. The coaching philosophy of the implemented model (Sackett & Gano-Overway, 2017). conducting the resulting research states that the main goal in training is capital and the key to success. The development of life skills for the players is carried out in an integrated manner in team training which aims to win the competition but the main priority is the development of the individual player's personality (Legg, 2021). Participation in sports can increase moral character, sportsmanship, and collaboration and cooperation between coaches, parents, and athletes are needed to achieve common goals (Pennington, 2017).

Conclusions

The training model based on comprehensive teaching-learning affects technical skills and social attitudes in young football players, although it is not significant. The factors that are predicted to influence the development of performance, personality, and the appropriate parameters accord-

ing to the growth and development of young players must be known by the managers, coaches, and parents involved in the training process. The philosophy, volume, load, and intensity of training in six months, years are important and contribute to the training goals of young soccer players. Future research should be carried out by paying attention to the development of skills that are more specific to differences in playing positions and performance in games.

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Conflict of interest

The authors declare that there are no conflicts of interest.

References

Bjørndal, C. T., & Ronglan, L. T. (2021). Engaging with uncertainty in athlete development–orchestrating talent development through incremental leadership. *Sport, Education and Society, 26*(1), 104-116. https://doi.org/10.1080/13573322.2019.1695198

Schroepf, B., & Lames, M. (2018). Career patterns in German football youth national teams: A longitudinal study. *International Journal of Sports Science & Coaching, 13*(3), 405-414. https://doi.org/10.1177/1747954117729368

Kavussanu, M., & Spray, C. M. (2006). Contextual influences on moral functioning of male youth footballers. *The Sport Psychologist, 20*(1), 1-23. https://doi.org/10.1123/tsp.20.1.1

Gilbert, W. D., Gilbert, J. N., & Trudel, P. (2001). Coaching strategies for youth sports: Part 1: Athlete behavior and athlete performance. *Journal of Physical Education, Recreation & Dance, 72*(4), 29-33. https://doi.org/10.1080/07303084.2001.10605736

Harwood, C. (2008). Developmental consulting in a professional football academy: The 5Cs coaching efficacy program. *The Sport Psychologist, 22*(1), 109-133. https://doi.org/10.1123/tsp.22.1.109

Henry, I. (2013). Athlete development, athlete rights and athlete welfare: A European Union perspective. *The International Journal of the History of Sport, 30*(4), 356-373. https://doi.org/10.1080/09523367.2013.765721

Wei, Y. D., Xiao, W., Wen, M., & Wei, R. (2016). Walkability, land use and physical activity. *Sustainability, 8*(1), 65-70. https://doi.org/10.3390/su8010065

Ekstrand, J., Lundqvist, D., Davison, M., D'Hooghe, M., & Pensgaard, A. M. (2019). Communication quality between the medical team and the head coach/manager is associated with injury burden and player availability in elite football clubs. *British Journal of Sports Medicine, 53*(5), 304-308. https://doi.org/10.1136/bjsports-2018-099411

Lawrason, S., Turnnidge, J., Martin, L. J., & Côté, J. (2019). A transformational coaching workshop for changing youth sport coaches' behaviors: A pilot intervention study. *The Sport Psychologist, 33*(4), 304-312. https://doi.org/10.1123/tsp.2018-0172

Goldberg, A. D., & Chandler, T. (1995). Sports Counseling: Enhancing the Development of the High School Student-Athlete. *Journal of Counseling & Development, 74*(1), 39-44. https://doi.org/10.1002/j.1556-6676.1995.tb01820.x

Pritchard, M., & Wilson, G. (2005). Comparing sources of stress in college student athletes and non-athletes. *Athletic Insight: The Online Journal of Sports Psychology, 5*(1), 1-8.

Wiese, D. M. (1988). Sport psychology for youth coaches: Personal growth to athlete excellence. *The Sport Psychologist, 2*(2), 175-177. https://doi.org/10.1123/tsp.2.2.175

Cresswell, S. L., & Eklund, R. C. (2007). Athlete burnout: A longitudinal qualitative study. *The Sport Psychologist, 21*(1), 1-20. https://doi.org/10.1123/tsp.21.1.1

Gencheva, N. (2015). Aggression in youth sthlets. *Research in Kinesiology, 43*(2), 205-209.

Bloodworth, A. J., Petróczi, A., Bailey, R., Pearce, G., & McNamee, M. J. (2012). Doping and supplementation: The attitudes of talented young athletes. *Scandinavian Journal of Medicine & Science in Sports, 22*(2), 293-301. https://doi.org/10.1111/j.1600-0838.2010.01239.x

Zhang, T., Deng, A., & Chen, A. (2020). The Missing Link? Middle School Students' Procedural Knowledge on Fitness. *Journal of Teaching in Physical Education, 1*(1), 1-10. https://doi.org/10.1123/jtpe.2019-0237

Brink, M. S., Visscher, C., Arends, S., Zwerver, J., Post, W. J., & Lemmink, K. A. (2010). Monitoring stress and recovery: new insights for the prevention of injuries and illnesses in elite youth soccer players. *British Journal of Sports Medicine, 44*(11), 809-815. https://doi.org/10.1136/bjsm.2009.069476

Zorzi, A., Vessella, T., De Lazzari, M., Cipriani, A., Menegon, V., Sarto, G., & Sarto, P. (2020). Screening young athletes for diseases at risk of sudden cardiac death: role of stress testing for ventricular arrhythmias. *European Journal of Preventive Cardiology, 27*(3), 311-320. https://doi.org/10.1177/2047487319890973

Hermassi, S., Bragazzi, N. L., & Majed, L. (2020). Body fat is a predictor of physical fitness in obese adolescent handball athletes. *International Journal of Environmental Research and Public Health, 17*(22), 8428-8434. https://doi.org/10.3390/ijerph17228428

Gerabinis, P., & Goudas, M. (2019). A Qualitative Investigation of Young Footballers' Perceptions Regarding Developmental Experiences. *Social Sciences, 8*(7), 215-223. https://doi.org/10.3390/socsci8070215

Collins, J., Maughan, R. J., Gleeson, M., Bilsborough, J., Jeukendrup, A., Morton, J. P., & McCall, A. (2021). UEFA expert group statement on nutrition in elite football. Current evidence to inform practical recommendations and guide future research. *British Journal of Sports Medicine, 55*(8), 416-416. https://doi.org/10.1136/bjsports-2019-101961

Smith, B., & McGannon, K. R. (2018). Developing rigor in qualitative research: Problems and opportunities within sport and exercise psychology. *International Review of Sport and Exercise Psychology, 11*(1), 101-121. https://doi.org/10.1080/1750984x.2017.1317357

Strachan, L., MacDonald, D. J., & Côté, J. (2016). Project score! Coaches' perceptions of an online tool to promote positive youth development in sport. *International Journal of Sports Science & Coaching, 11*(1), 108-115. https://doi.org/10.1177/1747954115624827

Bridge, M. W., & Toms, M. R. (2013). The specialising or sampling debate: A retrospective analysis of adolescent

sports participation in the UK. *Journal of Sports Sciences, 31*(1), 87-96. https://doi.org/10.1080/02640414.2012.721560

Farič, N., Potts, H. W., Hon, A., Smith, L., Newby, K., Steptoe, A., & Fisher, A. (2019). What players of virtual reality exercise games want: Thematic analysis of web-based reviews. *Journal of Medical Internet Research, 21*(9), 13833-13839. https://doi.org/10.2196/preprints.13833

Malina, R. M. (2010). Early sport specialization: Roots, effectiveness, risks. *Current Sports Medicine Reports, 9*(6), 364-371. https://doi.org/10.1249/jsr.0b013e3181fe3166

Boettcher, J., Filter, B., Denecke, J., Hot, A., Daubmann, A., Zapf, A., & Wiegand-Grefe, S. (2020). Evaluation of two family-based intervention programs for children affected by rare disease and their families–research network (CARE-FAM-NET): Study protocol for a rater-blinded, randomized, controlled, multicenter trial in a 2x2 factorial design. *BMC Family Practice, 21*(1), 1-11. https://doi.org/10.1186/s12875-020-01312-9

Leifer, E. S., Troendle, J. F., Kolecki, A., & Follmann, D. A. (2021). Joint testing of overall and simple effects for the two-by-two factorial trial design. *Clinical Trials, 18*(5), 521-528. https://doi.org/10.1177/17407745211014493

Fichera, E., & von Hinke, S. (2020). The response to nutritional labels: Evidence from a quasi-experiment. *Journal of Health Economics, 72*(1), 102326-102336. https://doi.org/10.1016/j.jhealeco.2020.102326

Aiken, L. S., West, S. G., & Reno, R. R. (1991). *Multiple regression: Testing and interpreting interactions.* Sage.

Subali, B., & Suyata, P. (2011). *Guide to analyzing educational measurement data to obtain empirical evidence of validity using the Quest program.* Yogyakarta: Institute for Research and Community Service at Yogyakarta State University.

Sumintono, B., & Widhiarso, W. (2015). *Rasch modeling application in educational assessments.* Trim Komunikata.

McGowan, J., Whatman, C., & Walters, S. (2020). The associations of early specialisation and sport volume with musculoskeletal injury in New Zealand children. *Journal of Science and Medicine in Sport, 23*(2), 139-144. https://doi.org/10.1016/j.jsams.2019.09.002

De Pero, R., Amici, S., Benvenuti, C., Minganti, C., Capranica, L., & Pesce, C. (2009). Motivation for sport participation in older Italian athletes: role of age, gender and competition level. *Sport Sciences for Health, 5*(2), 61-69. https://doi.org/10.1007/s11332-009-0078-6

Ali, A. (2011). Measuring soccer skill performance: a review. *Scandinavian Journal of Medicine & Science in Sports, 21*(2), 170-183. https://doi.org/10.1111/j.1600-0838.2010.01256.x

Stolz, S., & Pill, S. (2014). Teaching games and sport for understanding: Exploring and reconsidering its relevance in physical education. *European Physical Education Review, 20*(1), 36-71. https://doi.org/10.1177/1356336x13496001

Bloomfield, J., Polman, R., & O'Donoghue, P. (2007). Physical demands of different positions in FA Premier League soccer. *Journal of Sports Science & Medicine, 6*(1), 63-69.

O'Reilly, J., & Wong, S. H. (2012). The development of aerobic and skill assessment in soccer. *Sports Medicine, 42*(12), 1029-1040. https://doi.org/10.1007/bf03262310

Lloyd, R. S., & Oliver, J. L. (2012). The youth physical development model: A new approach to long-term athletic development. *Strength & Conditioning Journal, 34*(3), 61-72. https://doi.org/10.1519/ssc.0b013e31825760ea

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68-74. https://doi.org/10.1037/0003-066x.55.1.68

Standage, M., Duda, J. L., & Ntoumanis, N. (2005). A test of self-determination theory in school physical education. *British Journal of Educational Psychology, 75*(3), 411-433. https://doi.org/10.1348/000709904x22359

Kavussanu, M., & Boardley, I. D. (2009). The prosocial and antisocial behavior in sport scale. *Journal of Sport and Exercise Psychology, 31*(1), 97-117. https://doi.org/10.1123/jsep.31.1.97

García-García, P. A., Martínez, J. A., & González-Gómez, F. J. (2017). The influence of aggressiveness on the performance of football teams in Spain. International *Journal of Medicine and Sciences of Physical Activity and Sports, 17*(66), 17-26.

Camiré, M., & Trudel, P. (2010). High school athletes' perspectives on character development through sport participation. *Physical Education and Sport Pedagogy, 15*(2), 193-207. https://doi.org/10.1080/17408980902877617

Camiré, M., Trudel, P., & Bernard, D. (2013). A case study of a high school sport program designed to teach athletes life skills and values. *The Sport Psychologist, 27*(2), 188-200. https://doi.org/10.1123/tsp.27.2.188

MacDonald, D. J., Côté, J., & Deakin, J. (2010). The impact of informal coach training on the personal development of youth sport athletes. *International Journal of Sports Science & Coaching, 5*(3), 363-372. https://doi.org/10.1260/1747-9541.5.3.363

Fisher, L. A., Larsen, L. K., Bejar, M. P., & Shigeno, T. C. (2019). A heuristic for the relationship between caring coaching and elite athlete performance. *International Journal of Sports Science & Coaching, 14*(2), 126-137. https://doi.org/10.1177/1747954119827192

Gould, D., Collins, K., Lauer, L., & Chung, Y. (2007). Coaching life skills through football: A study of award-winning high school coaches. *Journal of Applied Sport Psychology, 19*(1), 16-37. https://doi.org/10.1080/10413200601113786

Bodey, K., Schaumleffel, N., Zakrajsek, R., & Joseph, S. (2009). A strategy for coaches to develop life skills in youth sport. *Journal of Youth Sport, 4*(2), 16-20.

Cappelen, A., List, J., Samek, A., & Tungodden, B. (2020). The effect of early-childhood education on social preferences. *Journal of Political Economy, 128*(7), 2739-2758. https://doi.org/10.1086/706858

Weller, M., Jordan, K., DeVries, I., & Rolfe, V. (2018). Mapping the open education landscape: Citation network analysis of historical open and distance education research. *Open Praxis, 10*(2), 109-126. https://doi.org/10.5944/openpraxis.10.2.822

Sackett, S. C., & Gano-Overway, L. A. (2017). Coaching life skills development: Best practices and high school tennis coach exemplar. *International Sport Coaching Journal, 4*(2), 206-219. https://doi.org/10.1123/iscj.2016-0080

Legg, E. (2021). The purpose of sport: perspectives of players, coaches, parents, and administrators. *Managing Sport and Leisure, 26*(2), 80-92. https://doi.org/10.1080/23750472.2020.1792800

Pennington, C. G. (2017). Moral development and sportsmanship in physical education and sport. *Journal of Physical Education, Recreation & Dance, 88*(9), 36-42. https://doi.org/10.1080/07303084.2017.1367745

ВПЛИВ КОМПЛЕКСНОГО НАВЧАЛЬНОГО ТРЕНУВАННЯ НА СОЦІАЛЬНІ НАВИЧКИ ТА УСТАНОВКИ

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Реферат. Стаття: 9 с., 6 табл., 54 джерела.

Мета дослідження – визначити вплив моделі комплексного навчального тренування на навички та соціальні установки юних футболістів.

Матеріали і методи. Дане дослідження є експериментальним із вибіркою з 36 спортсменів-футболістів чоловічої статі 10-12 років. Вибірка складалася з гравців, які тренувалися у футбольній школі Real Madrid Foundation у Джок'якарті. Досліджувані відвідували тренування 3 рази на тиждень з мінімальною відвідуваністю 80% за 20 тижнів і були відібрані для участі в районних або провінційних футбольних змаганнях. Для оцінки футбольних технічних навичок використовувався тест Девіда Лі, а для соціальних установок – анкета спортивної шкали просоціальної та антисоціальної поведінки (PABSS). Методом аналізу даних був t-критерій для парних вибірок.

Результати. Результати показали, що модель комплексного навчального тренування вплинула на навички та соціальні установки юних футболістів. У віковій групі 10 років вплив на навички становив 1,497, а на соціальну поведінку – 2,750, що свідчить про впливовість моделі. У віковій групі 11 років виявлено, що вплив на навички становив 0,506, а на соціальну поведінку – -2,812, тобто впливу на соціальну поведінку не спостерігалося. У віковій групі 12 років вплив на навички становив 0,19, а на соціальну поведінку – 1,148, що свідчить про дію моделі.

Висновки. Молоді футбольні тренери можуть обрати модель комплексного навчального тренування як стратегію для розвитку спортивних навичок та особистості.

Ключові слова: футбол, навички, соціальні установки, молодь.

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THE STRUCTURE OF GENERAL PHYSICAL FITNESS OF GIRLS – FUTURE OFFICERS DURING TRAINING AT THE MILITARY ACADEMY

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Abstract

The study objective consist in studied the structure, which marked the change in the general physical fitness of the same girls throughout the period of their studies at the military academy.

Materials and Methods. The study involved 108 girls, their age at the beginning of the study was 17-18 years. Taking into account the recommendations of experts, a battery of tests was used to assess the development of basic motor skills. Testing took place at the beginning of each new school year.

Results. Received evidence of this. During the training at the military academy, the general physical fitness of girls changes every year, which has its own structure with features that depend on the year of study. The first such structure is determined by static strength endurance, flexibility, speed qualities, and muscular force, during the second year of study – static strength endurance, aerobic endurance, and coordination in cyclic locomotions, during the third – flexibility, explosive force, and aerobic endurance, during the fourth – muscle strength, speed, and aerobic endurance.

Conclusions. Establishing the structure of physical fitness of girls – future officers during each year of study at the military academy is an important task. To improve the general physical fitness of girls – future officers, it is advisable to design the content of the program, taking into account the results. The program should focus on the development of motor skills that form a certain structure of change in the general physical fitness of girls in a given year of study.

Keywords: military academy, physical fitness, structure, program.

Introduction

The professional competence of the military of various ranks and any specialty is determined by a set of characteristics (Romanchuk et al., 2012; Duncan, 2016). However, one of the determinants continues to be physical fitness (Kennedy, & Neilson, 2002; Romanchuk et al., 2019; Padgett, 2016). In the Armed Forces and other paramilitary formations of Ukraine, such training is aimed at developing qualities that provide a high level of individual military-professional skills of a modern soldier, including instant assessment of the situation, speed, accuracy and maneuverability, physical and mental endurance (Guidelines, 2009).

In the leading armies of the North Atlantic Alliance, physical education and sports are one of the main means of developing professionally important qualities of future officers, in particular, leadership and team spirit, the ability to mobilize all forces to solve specific professional tasks, including in combat (Shchegolev, 2014; Duncan, 2016). As you can see, the fact of connection and dependence of professional competence of future officers on the state of their physical fitness does not need to be proved. This fully applies to girls – future officers (Boyarchuk, 2010; Sliusarchuk & Iedynak, 2015; Dobrovolsky, 2018). Due to the importance of physical fitness, researchers have studied it in future officers in various areas. According to studies by Ivashchenko et al. (2016), Melnykov et al. (2018), Romanchuk et al. (2020), one of these areas is related to the study of the factor structure of physical fitness of young people studying in various institutions of higher education. However, in this direction,

there are almost no studies on the physical fitness of girls – future officers during their training at the military academy (Boyarchuk, 2010; Dobrovolsky, 2018). This also applies to both components of such training, namely special and general (Slyusarchuk, Kedrych, & Dovgal, 2020; Slyusarchuk, Marchuk, V., & Marchuk, D., 2020; Slyusarchuk, 2020) In addition, there are no studies aimed at determining the structure of each component of physical fitness. In connection with the latter, we note the prospects of the approach, which involves the use of empirical data that reflect the change in each studied indicator over a period of time, rather than the manifestation of values at the time of their receipt. In other words, it is proposed to study the structure of change in general (special) physical fitness, rather than the manifestation of indicators of this fitness at a given time. The importance and necessity of information about the structure of change in physical fitness is related to the possibility to improve the content of training programs for physical training of girls – future officers, taking into account the dynamics of their performance during each year of training at the military academy. This will help increase the effectiveness of the programs used in terms of achieving the highest possible results.

Purpose of the research is studied the structure, which marked the change in the general physical fitness of the same girls throughout the period of their studies at the military academy.

Materials and methods

Study participants

The study involved the same 108 girls – future officers who studied in the military academies of Ukraine throughout the four years. At the beginning of the study, their age was in the range of 17-18 years. The focus was on general physical fitness, namely the structure of its change during each year of girls' education. The results of tests that took place at the beginning of each new year of study were given.

Study organization

To obtain the necessary data, a battery of tests was formed. These tests met the established requirements (Turvey & Fonseca, 2009; Schmidt & Lee, 2013) and contained the most common in the practice of physical education motor tasks (Eurofit, 1993; Fitness testing, 2017; Thomas, Nelson, & Silverman, 2011). What is physical fitness, 2017). Various motor qualities were investigated using the following tests: dynamometry (handgrip Camry dynamometer, back dynamometer from Baseline Products) – maximum isometric strength; jump in length from place – speed force of muscles of lower extremities; hanging on the arms bent at the elbows – static strength endurance; leaning forward sitting – flexibility; 30-m run test – speed qualities; 12-minute run to the maximum distance (Cooper-Test) – aerobic endurance; shuttle run 4×9 m –coordination in particular of cyclic locomotion.

Carrying out dynamometry assumed that the subject according to the instruction takes the device in a palm, lowers a hand downwards and takes away aside-outside on 15-20°. Then press your fingers on the appropriate part of the device with maximum force. Each girl performed this action three times, but the best result was taken into account; measurement accuracy – 0.5 kg. The "jump in length from place" test was performed in the gym on a specially marked area. This section provided: a starting line, which began the field to jump forward; starting from one meter from the start line to the left and right there was a marking every centimeter. The jump was performed as follows: the subject stood on the starting line so that the tips of the toes touch the inner edge of the line; after that she bent her legs at the knees, tilted her torso forward, and took her arms back, that is, took a position, as at the start of the swimmer. At the same time, the angle of bending in the knee joints, the tilt of the torso forward and the withdrawn arms, each girl chose for herself individually. Basic conditions: maximum convenience of the starting position to demonstrate the greatest result; after landing, the girl remained in place until the result was determined; the test was performed three times, taking into account the best result – the maximum length of the jump in centimeters, and the accuracy of measurement – 1 cm. To establish the result used laser level BOSCH_GLL_2-10-carton, which forms a laser beam sector for jumps with a mark and a point on the edge of the heel. If both heels were not on the same line after the jump, then use the point on the heel that is closer to the starting line. The test "hanging on the arms bent at the elbows" was performed on a high crossbar, the starting position of the "chin over the crossbar". With the beginning of the adoption of such a position, the stopwatch was turned on, and turned off when the girl reached the position of "bar below eye level". The test involved one attempt, performed after a preliminary preparation of exercises for the muscles and joints of the upper extremities; measurement accuracy one second. The test "leaning forward sitting" provided: the starting position "sit, legs apart", while performing the tilt with your hands to stretch forward as far as possible, legs at the knees do not bend; after the maximum possible tilt forward determine the result of the girl with an accuracy of one centimeter. The starting point was the third finger, and the zero mark was at the level of the girl's back; on both sides of the tilt sector, there was a marking every inch. Three attempts were made, taking into account the best result. The instrument and method of determining the result were similar to those used in the "long jump" test. The "30 m run" test was performed as follows: from the "high start" position on the team of the teacher, two girls started running with the maximum possible speed to the finish line; determined the time of overcoming the distance. The teacher and his assistant were at the finish line, the teacher gave the command to start the run (lowering the flag from top to bottom) and at the same time turned on the stopwatch. His assistant did the same, and he recorded the result of the girl who finished second, and the teacher – the result of the winner. The measurement accuracy was 0.1 s. The organization and methodology of the 12-minute long-distance run or Cooper's running test did not differ from the existing recommendations of this American researcher. In particular, girls are asked to cover the maximum distance during the specified time, using running and walking. It is allowed to arbitrarily switch from running to walking and vice versa. Along the entire length of the treadmill, there are flags, the distance between them is 20 m. On the command of the teacher "Rush" girls from a high start running. The teacher records the number of complete circles that the girls have overcome, and after

12 minutes gives the command "Stop". The girls immediately stop on the spot, the teacher records the distance of the incomplete circle, which each girl overcame, guided by the flag: to the number of complete circles he adds the distance of the incomplete circle; such a distance is determined by the number of flags at that distance, which are multiplied by the distance between them (20 m); measurement accuracy – up to 10 m. When performing the test "shuttle run 4 × 9 m" took into account the generally accepted organization and methodology (Omorczyk, Lah, 2009). The main ones in terms of equipment are as follows: a track 10 m long is limited by two parallel lines; for each two semicircles of 0.5 m with the center on the line; two stuffed balls, Casio stopwatch with a measurement accuracy of 0.01 s. The method of the test included: on the team of the teacher "On the start" the girl took the starting position "high start" on the starting line on either side of the stuffed ball; under the Rush team, the girl overcame the first 9 m, ran around the stuffed ball from the right side, then overcame the second section of 9 m and ran around the stuffed ball again, then repeated the above steps twice and finished. The test execution time was recorded, the result was determined with an accuracy of 0.1 s, two attempts were made, and the best result was taken into account.

Statistical analysis

All statistical analyzes were performed using SPSS Version 21. The test results were processed using factorial analysis, which involved determining the major components and using varimax rotation to normalize the data (Khalafian, 2007). In this case, only statistically significant values were taken into account, namely at the level of $\alpha = 0.05$. The organization of the study took into account the provisions of the Гельсінської декларації of the World Medical Association (WMA-2013) on the ethical principles of medical research with human participation; the research protocol was approved by the ethics commission of Taras Shevchenko National University "Chernihiv Collegium".

Results

During the first year of training for girls – future officers, the change in their general physical fitness was characterized by a structure formed by five statistically independent factors. The total contribution of the four factors to the total variance was 71%. This indicated that the contribution of other, unidentified factors, was at the level of 29% (Table 1-3). The most important indicator of the first factor was hanging on the arms bent at the elbows. Its factor load was 0.745 ($p<0.05$), and the contribution of the factor to the total variance was 19.6%.

The contribution of the second factor to the total variance was 18.7%, the most important indicator here is the forward sitting ($r = 0.778$; $p < 0.05$).

The contribution of the third factor to the total variance was at the level of 16.9%, the most important indicator on this factor was running 30 m, the factor load of this indicator was (-0.844) ($p <0.05$).

The fourth factor was characterized by the following features: the contribution to the total variance – 15.8%, the most important indicator on this factor – the dynamometry of the hand, its factor load – (-0.921) ($p < 0.05$).

Table 1. Evaluation of the Feasibility of Applying Factor Analysis to change the girl's physical fitness during the first year of study

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO)		0.507
Bartlett's Test of Sphericity	Approx. Chi-Square	37.489
	Df	21
	Sig.	.015

Table 2. Results of Factor Analysis. Rotated Component Matrix in the change of the girl's physical fitness during the first year of study

No	Indicator	Component				h^2
		1	2	3	4	
1.	Running 30 m	-.187	.241	-.844	.090	.782
2.	Wrist dynamometry	-.015	.019	.020	-.921	.773
3.	Long jump from a place	.721	.096	.243	-.173	.648
4.	Leaning forward while sitting	.086	.778	-.025	.182	.651
5.	Shuttle run 4×9 m	-.493	.342	.621	.203	.800
6.	12-minute run	-.105	-.711	.100	.338	.581
7.	Hanging on the crossbar	.745	.123	-.121	.185	.585

Table 3. Total Variance Explained in the change of of the girl's physical fitness during the first year of study

Component	Rotation Sums of Squared Loadings	
	% of Variance	Cumulative %
1	19.600	19.600
2	18.723	39.433
3	16.885	55.891
4	15.821	71.029

Thus, during the first year of training of girls – future officers in the military academy, the change in their general physical fitness by 71% was due to a change in the development of static strength endurance, flexibility, speed and muscle strength. As for the remaining 29%, they contained other, but we have not established the motor abilities of girls.

During the second year of study, the structure of changes in the general physical fitness of girls – future officers differed from that established one year earlier. Thus, this structure was formed by four independent factors, namely three determined it by 62.3%; the remaining 37.7% combined other factors, but we did not identify them. The most important indicator of the first factor was hanging on the arms bent at the elbows. The contribution of this factor to the total variance was 21%, and the factor load was 0.756 ($p < 0.05$). The peculiarity of the second factor was as follows: the most important indicator – Cooper-Test, its factor load – 0.860 ($p < 0.05$), the contribution of the factor to the total variance – 22.1% (Table 4-6).

The third factor also contained only one of the most important indicators. Such an indicator was coordination in cyclic locomotions, its contribution was 19.2%, and the factor load was 0.787 ($p < 0.05$).

Table 4. Evaluation of the Feasibility of Applying Factor Analysis in the change of the girl's physical fitness during the second year of study

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO)		0.501
Bartlett's Test of Sphericity	Approx. Chi-Square	40.210
	Df	21
	Sig.	.013

Table 5. Results of Factor Analysis. Rotated Component Matrix in the change of the girl's physical fitness during the second year of study

No	Indicator	Component			h^2
		1	2	3	
1.	Running 30 m	-.283	-.173	.551	.414
2.	Wrist dynamometry	.672	-.137	.558	.781
3.	Long jump from a place	.598	.097	-.265	.437
4.	Leaning forward while sitting	.034	.853	.072	.733
5.	Shuttle run 4×9 m	-.090	.134	.787	.646
6.	12-minute run	.059	.860	-.109	.755
7.	Hanging on the crossbar	.756	.056	-.152	.598

Table 6. Total Variance Explained in the change of the girl's physical fitness during the second year of study

Component	Rotation Sums of Squared Loadings	
	% of Variance	Cumulative %
1	21.046	21.046
2	22.121	44.448
3	19.189	62.343

Thus, during the second year of training of girls – future officers in the military academy, the change in their general physical fitness by 62.3% was due to the change in static endurance, aerobic endurance and coordination in cyclic locomotions; the remaining 37.7% contained non-established motor abilities.

During the third year of training of girls – future officers, it was found that the change in their general physical fitness is characterized by a structure formed by four statistically independent factors. The total contribution of three of them to the total variance was 55%, the contribution of other, but not established by us, factors was at the level of 45%. At the same time, only one of the most important indicators was singled out on the first factor, and it was the inclination of sitting forward. The factor load of this indicator was ($r = -0.831$; $p < 0.05$), and the contribution of the factor to the total variance was 16.7% (Table 7-9).

The second factor also identified only one of the most important indicators. It was a long jump from a place, the factor load of which was 0.667 ($p < 0.05$), and the contribution to the total variance was 19.9%.

The third factor was marked by the contribution to the total variance at the level of 18.4%. The most important indicator of this factor was Cooper-Test, and the value of its factor load was 0.742 ($p < 0.05$).

Table 7. Evaluation of the Feasibility of Applying Factor Analysis to change the girl's physical fitness during the third year of study

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO)		0.599
Bartlett's Test of Sphericity	Approx. Chi-Square	34.452
	Df	21
	Sig.	.032

Table 8. Results of Factor Analysis. Rotated Component Matrix to change the girl's physical fitness during the third year of study

No	Indicator	Component			h^2
		1	2	3	
1.	Running 30 m	.526	.312	.434	.562
2.	Wrist dynamometry	-.001	.655	.135	.447
3.	Long jump from a place	.251	.667	-.236	.562
4.	Leaning forward while sitting	-.831	.113	.005	.704
5.	Shuttle run 4×9 m	.257	.092	.658	.507
6.	12-minute run	-.125	.012	.742	.566
7.	Hanging on the crossbar	-.219	.635	.212	.496

Table 9. Total Variance Explained to change the girl's physical fitness during the third year of study

Component	Rotation Sums of Squared Loadings	
	% of Variance	Cumulative %
1	16.659	16.659
2	19.910	40.609
3	18.434	54.912

Given the above, the change in the general physical fitness of girls – future officers during the third year of training by 55% was due to changes in flexibility, explosiveness and aerobic endurance; the remaining 45% contained unidentified motor abilities.

In the last year of training, the data obtained showed four statistically independent factors that determine the change in the general physical fitness of girls – future officers. At the same time, the total contribution of the three factors was 60.6%, and the remaining 39.4% were unidentified factors. The specification of the selected factors indicates that the first factor contained one indicator with a statistically significant value of the factor load. This indicator was the dynamometry of the hand, and the value of the factor load was 0.744 ($p < 0.05$) (Table 10-12).

The contribution of the second factor to the total variance was equal 18.7%. To a large extent, this volume was formed by one indicator, namely running 30 m, as it was marked by the largest factor load, which was (-0.699) ($p < 0.05$).

On the third factor, only one indicator was singled out, but the contribution to the total variance was 17.2%. Such an indicator was Cooper-Test, and the value of the factor load – (-0.889) ($p < 0.05$).

Given the above data, it was noted that the change in the general physical fitness of girls – future officers during

Table 10. Evaluation of the Feasibility of Applying Factor Analysis Matrix in the change of the girl's physical fitness during the fourth year of study

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO)		0.504
Bartlett's Test of Sphericity	Approx. Chi-Square	40.010
	Df	21
	Sig.	.011

Table 11. Results of Factor Analysis. Rotated Component Matrix in the change of the girl's physical fitness during the fourth year of study

No	Indicator	Component			h^2
		1	2	3	
1.	Running 30 m	.229	-.699	-.202	.582
2.	Wrist dynamometry	.744	.004	.042	.555
3.	Long jump from a place	.448	.473	.238	.481
4.	Leaning forward while sitting	.650	-.174	.119	.467
5.	Shuttle run 4×9 m	.081	.672	-.278	.536
6.	12-minute run	.124	.051	-.889	.809
7.	Hanging on the crossbar	.692	.329	-.469	.808

Table 12. Total Variance Explained Matrix in the change of the girl's physical fitness during the fourth year of study

Component	Rotation Sums of Squared Loadings	
	% of Variance	Cumulative %
1	24.714	24.714
2	18.651	43.363
3	17.161	60.524

the fourth year of training by 60.6% was due to changes in muscle strength, speed and aerobic endurance, while the remaining 39.4% – a change in undetected motor abilities.

Discussion

Establishing the structure of physical fitness of girls – future officers during each year of study at the military academy is an important task. This is primarily due to the ability to identify the components of physical fitness on which it depends the most (Ivashchenko et al., 2016; Melnykov et al., 2018). In practical terms, such data can contribute to the formation of a training program that takes into account the identified dependence. In particular, the content of the program focuses on the development of motor skills that form the established structure.

The obtained data allowed to establish the motor qualities to which the training program should give priority status in a certain year of girls' education. Thus, during the first two years of study, one of the leading places in the structure of changes in the general physical fitness of girls was occupied by static strength endurance, and during the second or fourth years of study – aerobic endurance. As for the other studied components of general physical fitness, there is another feature. It consisted in the fact that during a certain year of study, motor qualities were additionally singled out, which also occupied a leading place in the structure of change. For example, during the first and third years of girls' training, this quality was flexibility, during the first and fourth years – speed and muscle strength, during the second year – coordination in cyclic locomotions, during the third – explosive force.

The identified features were associated with a set of reasons, one of which is a sensitive period of development of motor quality. Thus, for muscle strength, this is the period of 17-18 years (Balsevich, 2000), ie during the first year of girls' training at the military academy. The data obtained showed a significant improvement in this motor quality during the first year of girls' education and a tendency to deteriorate during the fourth. In the latter case, the result was associated with a lack of loads in the training program used to develop this motor quality. This age period, although not sensitive to the development of muscle strength, but here you can also achieve a positive result. The main condition for this is a larger amount of training loads than in the case when the motor quality is in the sensitive period (Katzmarzyk & Silva, 2013). The use of such amounts of training will not only improve the muscular strength of girls, but also a positive change in the state of general physical fitness. This is due to the cross-effect, which may form the basis of cumulative adaptation, which is formed in girls (Wilmore, Costill, & Kenney, 2012). The essence of this effect is the development of motor quality or several that were not exercised (Schmidt & Lee, 2013).

For another motor quality, which was distinguished in girls, namely explosive power, the period of 19 and 22 years is sensitive (Radzinska, 1999). The obtained data are to some extent consistent with the above: during the third year of study at the military academy, the explosive power of the girls – the future officers of the girl showed a tendency to improve. This slight change was explained by the lack of loads in the training program used to ensure the development of explosive power. This is one of the determining reasons for the lack of significant growth in the level of development of any motor quality (Wuest & Bucher, 2005).

A similar conclusion was made after analyzing the data on the positive trend, which marked the state of development of coordination in running, because sensitive for girls is the period of 17-19 years (Balsevich, 2000).

As for the static strength endurance of girls, the sensitive period is 17-18 years, for endurance during the dynamic mode of operation in the zone of maximum and submaximal intensity – 17 years (Kuramshin, 1998), general coordination – 19-20 years (Karpeev, 1998). This was considered as the main reason for the separation of static strength endurance in the structure of changes in the general physical fitness of girls during the first two years of study. The need for a targeted impact on this motor quality was also confirmed by the data of its changes, namely a significant improvement during the first and a positive trend during the second year of study.

Other motor qualities, identified in the structure of changes in the general physical fitness of girls – future officers, to some extent consistent with existing information. In particular, the aerobic endurance of girls at the age of

17 reaches high values, but usually does not exceed 90% of the level of an adult. Therefore, the period of 15-20 years is considered sensitive, and the maximum values of girls reach 25 years (Bergtraum, 2020). Such information is to some extent consistent with the data obtained on the change in the state of development of this motor quality. The change is positive during the second, negative during the third year of study, and during the fourth shows a significant improvement. One of the reasons for the negative trend in the change of the state of development of this motor quality was associated with the inadequate amount of loads of the corresponding orientation, which were provided by the training program of the girls.

The interpretation of data related to speed qualities was similar, except for the following: the period up to 14 years is sensitive, maximum values are reached at 15 years, but some characteristics can improve up to 25 years and even later (Balsevich, 2000; Katzmarzyk & Silva, 2013; Bergtraum, 2020). As for flexibility, its development can occur after the most favorable adolescence, in particular during 18-25 years and even later; but a positive result is provided by a very large number of repetitions of each such exercise (Alter, 2004). According to our data, the flexibility of girls improved significantly during the first year of study, but deteriorated during the fourth. In the latter case, this result was associated with the lack of loads aimed at developing this motor quality, which were provided by the training program used by the girls.

Conclusions

During training at a military academy, the general physical fitness of girls – future officers changes every year, which has its own structure with features that depend on the year of study. During the first such structure is determined by static strength endurance, flexibility, speed qualities and muscular force, during the second year of study – static strength endurance, aerobic endurance and coordination in cyclic locomotions, during the third – flexibility, explosive force and aerobic endurance, during the fourth – muscle strength, speed and aerobic endurance. To improve the general physical fitness of girls – future officers, it is advisable to design the content of the program, taking into account the results. The program should focus on the development of motor skills that form a certain structure of change in the general physical fitness of girls in a given year of study.

Conflict of interest

The authors state no conflict of interest.

References

Romanchuk, S.V., Gryban, G.P., Romanchuk, V.M., Finogenov, Yu.S., & Petryshyn, Yu.V. (2012). *Physical education in the system of military-professional activity: textbook. manual.* Lviv: DIA. (in Ukrainian)

Duncan, A.G. (2016). *The military education of junior officers in the Edwardian Army.* Birmingham: History Department College of Arts and Law University.

Kennedy, G., & Neilson, K. (2002). *Military Education: Past, Present, and Future.* London: Greenwood Publishing Group.

Romanchuk, S., Iedynak, G., Kopylov, S., Galamandjuk, L., Melnykov, A., Afonin, V., Oderov, A., Klymovych, V., Pylypchak, I., & Nebozhuk, O. (2019). Factors that influence changes in cadets' physical preparation during the second half of study at a military academy. *Revista Dilemas Contemporáneos: Educación, Política y Valores, Year VII, Special Edition, November.* https://doi.org/10.46377/dilemas.v30i1.1195

Padgett, S.J. (2016). *Commander's Fitness Program.* Infantry, 4, 36-39.

Guidelines for physical training in the Armed Forces of Ukraine (NFP-2009). (2009). Kyiv: Ministry of Defense of Ukraine. (in Ukrainian)

Shchegolev, V.A. (2014). Physical training in the US military educational systems. *Theory and practice of physical culture,* 9, 55-6013.

Boyarchuk, O.M. (2010). *Physical training of the female contingent of the Armed Forces of Ukraine in the system of professional activity: author's ref.* Candidate of Dissertation Sciences in Phys. education and sports: 24.00.02 Lviv state. University of Phys. culture. Lviv. 20 p. (in Ukrainian)

Sliusarchuk, V., & Iedynak, G. (2015). Physical education of future woman-officers of the state border service for formation of readiness to physical self-development at academy education as a pedagogical problem. *Journal of Education, Health and Sport, 5*(7), 690-698. http://doi.org/10.5281/zenodo.2539671

Dobrovolsky, V.B. (2018). *Improving the physical training of female cadets of higher military educational institutions: dissertation.* Sciences in Phys. Education and Sports: 24.00.02 Military Institute of Kyiv National in the name of Taras Shevchenko. Kyiv. (in Ukrainian)

Ivashchenko, O., Khudolii, O., Yermakova, T., Iermakov, S., Nosko, M., & Nosko, Y. (2016). Factorial and discriminant analysis as methodological basis of pedagogic control over motor and functional fitness of 14-16 year old girls. *Journal of Physical Education and Sport, 16*(2), 442-451. https://doi.org/10.7752/jpes.2016.02068

Melnykov, A., Iedynak, G., Galamandjuk, L., Blavt, O., Duditska, O., Koryagin, V., Balatska, L., & Mazur, V. (2018). Factors that influence change in cadets' physical preparation during the first half of study at the military academy. *Journal of Physical Education and Sport, 18*(2), 781-786. https://doi.org/10.7752/jpes.2018.02115

Romanchuk, S., Anokhin, E., Tychyna, I., Dobrovolskii, V., Pidleteichuk, R., Homanyuk, S., Kirpenko, V., Oderov, A., & Klymovych, V. (2020). The Impact of Mass Sports Work in Educational Institution on the Formation of Cadets' Value Attitude Towards Physical Education. *Sport Mont,18*(1), 81-86. https://doi.org/10.26773/smj.200214

Slyusarchuk, V., Kedrych, G., & Dovgal, V. (2020). Dynamics of special physical fitness of girls – future officers during training in a higher military educational institution. *Bulletin of Kamyanets-Podilsky National University named after Ivan Ogienko. Series: Physical education, sports and human health,* 17, 74-79. https://doi.org/10.32626/2309-8082.2020-17.74-79

Slyusarchuk, V., Marchuk, V., & Marchuk, D. (2020). Comparison of the general physical fitness of girls – future border guards and the Armed Forces of Ukraine during the first year of study at military academies. *Bulletin of Kamyanets-Podilsky National University named after Ivan Ogienko. Series: Physical education, sports and human health,* 18, 44-50. https://doi.org/10.32626/2309-8082.2020-18.44-50

Slyusarchuk, V. (2020). General physical fitness of girls – future officers at the stages of training in military academies. *Bulletin of Kamyanets-Podilsky National University named after Ivan Ogienko. Series: Physical education, sports and human health,* 19, 54-60. https://doi.org/10.32626/2309-8082.2020-19.54-60

Turvey, M.T., & Fonseca, S. (2009). Nature of motor control: perspectives and issues. *Advances in Experimental Medicine and Biology,* 629, 93-123. https://doi.org/10.1007/978-0-387-77064-2_6

Schmidt, R. A., & Lee, T. (2013). *Motor learning and performance: from principles to application.* Champaing, IL: Human Kinetics.

Eurofit, (1993). *Eurofit Tests of Physical Fitness,* 2nd ed. Strasbourg.

Fitness testing, http://www.teachpe.com/fitness/testing.php

Thomas, J. R., Nelson, J. K., & Silverman, S. J. (2011). *Research methods in physical activity.* 6th ed. Champaign, IL: Human Kinetics.

Omorczyk, J., & Lah, V.I. (2009). Dynamika zmian poziomu koordynacyjnych zdolności motorycznych u studentek AWF w Krakowie. *Young sports science of Ukraine,* 3, 122-128.

Khalafian, A.A. (2007). *Statistical analysis of data.* Moscow: LLC "Bean Press".

Balsevich, V.K. (2000). *Human Ontokinesiology.* M.: Theory and practice of physical culture.

Katzmarzyk, P.T., & Silva, M.J.C. (2013). *Growth and maturation in human biology and sports.* Coimbra: University press.

Wilmore, J.H., Costill, D.L., & Kenney, L.W. (2012). *Physiology of sports and exercise.* 5th ed. Champaign, IL: Human Kinetics.

Radzinska, M. (1999). Critical periods in the development of jamping abilities. In: V. Strojnik and A. Usaj, eds. *Proceedings I of the Sport Kinetics Conference'99, Ljubljana, Slovenia, University of Ljubljana, Faculty of Sport,* September 1st – 4th; 289-291. https://doi.org/10.5152/tjsm.2019.148

Wuest, D.A., & Bucher, C.A. (2005). *Foundations of physical education and sport.* Mosby: Year Book Inc.

Kuramshin, Yu.F. (1998). *Theory and methodology of physical culture.* SPb: SPbGAFK im. PF Lesgaft.

Karpeev, A.G. (1998). *Human motor coordination in sports exercises of ballistic type: monograph.* SibGAFK.

Bergtraum, D.I. (2020). *Physiological features of the impact of physical activity on athletes of different ages and genders: a lecture.* Ivan Bobersky Lviv State University of Physical Culture.

Alter, M.J. (2004). *Science of Flexibility (Third Edition).* Champaign, Ill.: Human Kinetics.

СТРУКТУРА ЗАГАЛЬНОЇ ФІЗИЧНОЇ ПІДГОТОВЛЕНОСТІ ДІВЧАТ – МАЙБУТНІХ ОФІЦЕРІВ ПІД ЧАС НАВЧАННЯ У ВІЙСЬКОВІЙ АКАДЕМІЇ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 8 с., 12 табл., 32 джерела.

Мета дослідження полягала у вивченні структуру, якою відзначалася зміна загальної фізичної підготовленості тих самих дівчат протягом усього періоду їхнього навчання у військовій академії.

Матеріали та методи. У дослідженні взяло участь 108 дівчат, їхній вік на початку дослідження становив 17-18 років. Ураховуючи рекомендації фахівців, використовували батарею тестів, що дозволяла оцінити розвиток основних рухових якостей. Тестування відбувалося на початку кожного нового навчального року.

Результати. Одержали дані, що свідчать про таке. Під час навчання у військовій академії в загальній фізичній підготовленості дівчат щороку відбувається зміна, що має свою структуру з особливостями, які залежать від року навчання. Протягом першого визначають таку структуру – статична силова витривалість, гнучкість, швидкісні якості й м'язова сила, протягом другого року навчання – статична силова витривалість, аеробна витривалість і координація у циклічних локомоціях, протягом третього – гнучкість, вибухова сила й аеробна витривалість, протягом

четвертого – м'язова сила, швидкісні якості та аеробна витривалість.

Висновки. Встановлення структури фізичної підготовленості дівчат – майбутніх офіцерів під час кожного року навчання у військовій академії є важливим завданням. Для поліпшення загальної фізичної підготовленості дівчат – майбутніх офіцерів доцільно проектувати зміст відповідної програми, враховуючи одержані результати. Програма повинна передбачати акцент на розвиток рухових якостей, що утворюють визначену структуру зміни в загальній фізичній підготовленості дівчат у певний рік навчання.

Ключові слова: військова академія, фізична підготовка, структура, програма.

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ORIGINAL SCIENTIFIC ARTICLE

LIMITED IMPLEMENTATION OF THE FIFA 11+ SHOULDER INJURY PREVENTION PROGRAM (FIFA 11+ S) AMONG PROFESSIONAL SOCCER GOALKEEPERS

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Abstract

Purpose. Soccer is one of the most popular sports worldwide. Soccer goalkeepers are more likely than outfield players to injure their upper extremities, particularly their shoulders. The Fédération Internationale de Football Association (FIFA) 11+ Shoulder Injury Prevention Program (FIFA 11+S) was developed to prevent upper extremity injuries. The aim of this study was to assess soccer goalkeepers' and goalkeepers' coaches' awareness, implementation, and opinion of FIFA 11+S effectiveness in reducing upper extremity injuries.

Materials and methods. A self-administered questionnaire was developed and distributed to worldwide professional soccer goalkeepers and goalkeepers' coaches. The survey was available in 10 different languages. The questionnaire consisted of questions covering the awareness, implementation, and goalkeepers' and goalkeepers' coaches' opinion of the FIFA 11+ Shoulder Injury Prevention Program in reducing upper extremity injuries. Questions development was guided by several authors expert in sport medicine and injury prevention programs.

Results. A total of 722 goalkeepers and goalkeepers' coaches completed the survey. The vast majority (97.60%) of the participants were goalkeepers. Only 204 (28.25%) participants were aware of FIFA 11+S, and 155 (21.46 %) were implementing FIFA 11+S in their current practice. Participants who implemented FIFA 11+S reported a positive opinion about the program efficacy, with a score of 8.19 ± 0.93 out of 10.

Conclusions. This study is the first to investigate goalkeepers' and coaches' awareness, implementation, and opinion of the effectiveness of the FIFA 11+S program in reducing shoulder injuries globally. Overall, the awareness rate was exceptionally low, but the implementation level among aware participants was good. Goalkeepers and coaches attained a positive score regarding the FIFA 11+S effectiveness in reducing shoulder injuries. Further efforts and research are needed to increase the awareness and usage of the FIFA 11+S program.

Keywords: football, shoulder trauma, upper extremity, surveys, questionnaires.

Introduction

Soccer (which is also known as football) dominates the global sporting world; there are a total of 275 million male and female players internationally (Tomlinson, 2014). The Fédération Internationale de Football Association (FIFA) assumes a governance role for the sport while also overseeing the organization of international competitions, such as the World Cup, which occurs every 4 years (Longo et al., 2012). Previous studies have shown that elite soccer players sustain 1.5-7.6 injuries for every 1,000 hours of training, while 12-35 injuries may occur for every 1,000 match hours (Ejnisman et al., 2016). Previous studies have also revealed that lower limb injuries are the most frequently occurring injuries

(67.7%), while upper limb injuries account for 13.4% of all cases (Ejnisman et al., 2016). During the World Cup that was held in Athens in 2004, 3.8% of athletes sustained a shoulder injury; while a slightly higher percentage (4.4%) was recorded for the same injury during the European Football Championship in 2004 (Ejnisman et al., 2016). Most shoulder-related injuries affect the glenoid labrum (84%); whereas labral injuries with associated rotator cuff involvement are less likely to occur (8%) (Ejnisman et al., 2016). A similar proportion (8%) was found for isolated rotator cuff injuries (Ejnisman et al., 2016). Sports injuries are usually associated with considerable costs, which places financial burden on injured players in terms of funding surgical interventions or rehabilitation programs. Furthermore, being forced to withdraw from sporting participation owing to injuries may adversely affect athletes' overall health and well-being (Al Attar et al., 2021).

Most shoulder injuries gradually manifest over a period of time, with chronic strain conditions resulting from overload (Cools, Johansson, Borms, & Maenhout, 2015). Overhead athletes may experience chronic shoulder pain because of repeated exposure to exercise arising from the principle of adaptation. Other contributory factors include changes in strength, flexibility, and posture, which may occur in the glenohumeral joint and other kinetic chain links (Cools et al., 2015). Thus, shoulder-related injuries indicate a clear need to develop prevention strategies. Furthermore, the identification of risk factors associated with shoulder injuries may be essential in their prevention (Asker et al., 2018).

Depending on the nature of sport, overhead athletes may be exposed to various levels of risk of sustaining shoulder injuries. For example, athletes who are engaged in contact sports were found to be at a greater risk of experiencing traumatic shoulder injuries (Asker et al., 2018). In addition, the key characteristic associated with overhead sports is the need to perform repeated overhead movements (Asker et al., 2018). Therefore, similarities may be observed between the mechanisms that can cause non-traumatic shoulder injuries and those that are required to participate in overhead sporting activities (Asker et al., 2018). Furthermore, age and gender-related variations may have a link to shoulder injuries, as evidenced by different anatomical positioning seen in diverse types of sports. Biomechanical risk factors are also important to consider; impaired shoulder functioning and coordination or poor throwing techniques may increase the risk of developing shoulder injuries during overhead sports (Asker et al., 2018). Accordingly, in seeking to address these challenges, sport injury prevention programs (IPPs) have been the subject of significant attention over recent years (Al Attar et al., 2016).

Based on the well-established FIFA 11+IPP, which has a proven record of accomplishment in preventing injuries, the FIFA 11+ Shoulder IPP (FIFA 11+S) program adopts a similar format (Ejnisman et al., 2016). A collaborative effort between leading global experts in the fields of orthopedics, physiotherapy, and sports rehabilitation with a particular interest in shoulder injuries led to the development of the FIFA 11+S program (Ejnisman et al., 2016). Ensuring that all sporting activities are performed correctly is critical to its success. Thus, coaches are essential in overseeing its implementation and advising the players, if required, on how to perform the exercises to ensure optimal benefit (Ejnisman et al., 2016). FIFA 11+S injury prevention program was used by Al Attar et al. (2021), who observed a reduction of 50% in upper extremity injuries among soccer goalkeepers compared to using normal warm-ups. The FIFA 11+S program can be divided into three main parts. Part I consists of general warm-up activities, while Part II focuses on building strength and balance for the shoulder, elbow, wrist, and finger muscles. Finally, in Part III, participants engage in a series of advanced exercises to strengthen core stability and muscle control. The program requires 20-25 min to complete in full, and it is typically used instead of normal warm-up activities before training practice (Ejnisman et al., 2016). All exercises included in the program pay particular attention to players' skills such as core stability, neuromuscular control, eccentric rotator strength, and agility (Ejnisman et al., 2016). It is recommended that these exercises are performed three times per week, and they should be incorporated into the training sessions of soccer goalkeepers. Part I usually requires 7 min to complete as part of general warm-up activities. Part II aims to enhance participants' strength and local muscular endurance. Program developers recommend that these exercises are performed for 9–10 min using a combination of low-resistance (light tubing strength or 2-3 kg) and high-resistance (three sets of 15-20 repetitions) approaches. Program developers also suggest that these exercises should be adapted based on the tolerance levels of individual athletes. The aim of exercises outlined in Part III is to increase muscular endurance; therefore, participants are required to perform activities at high velocity with either 5 or 6 sets of 15-20 repetitions (Ejnisman et al., 2016).

Therefore, this study aims to assess soccer goalkeepers and goalkeepers' coaches' awareness, implementation, and opinion of FIFA 11+S in reducing upper extremity injuries.

Materials and methods

Study Design and Questionnaire

Based on the study objective, a questionnaire was developed by the study authors to collect information about the awareness, knowledge, and opinion of goalkeepers and coaches, along with their views regarding the FIFA 11+S program. The developed questionnaire was validated through pilot testing that was performed before beginning the study. The study was a cross-sectional survey that targeted goalkeepers and coaches from different continental football federations. The questionnaire consisted of sociodemographic questions that included: gender, age, type (goalkeeper or coach), and the country. The second section was on the awareness, where participants were asked whether they were aware of the FIFA 11+S program; the participants could answer yes or no. The third section was on the implementation (yes or no) and was supposed to be answered only by aware participants. Then, participants who reported implementing the FIFA 11+S program were asked about their opinion regarding the program effectiveness in the prevention of shoulder injuries on a 10-points scale from 0 (ineffective) to 10 (highly effective). The survey was available in Arabic, Chinese, English, French, German, Italian, Japanese, Portuguese, Russian, Spanish, and Turkish. This study was reviewed and ethically approved by the Biomedical Ethics Committee at Umm Al Qura University, approval number: HAPO02K012202011487.

Questionnaire Administration

The survey was uploaded to the well-known online survey software Google Forms (Alphabet Inc., Mountain View, California, United States). The link was sent to the goalkeepers and coaches from different Football Federations; the purpose of the survey was outlined, and survey questions were provided. The link was limited to one responder only. Participants were informed that their participation was voluntary, and that all data would be kept anonymous, confidential, and used for research purposes only. Responses were collected from June 2019 to June 2020.

Sample Size and Statistical Analysis

Considering a 4% margin of error at 95% confidence level, the target number was 900 participants. Responses were organized in Microsoft Excel 2019 (Microsoft Corp., Redmond, Washington, United States). The data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 24.0 (IBM Corp., Armonk, New York, United States). Descriptive statistics were presented as percentages. Percentages with a 95% confidence interval (CI) are reported. The p-value of 0.05 was set as statistically significant.

Results

The total number of respondents was 722 goalkeepers and coaches; most of them were males (95%), while females represented only 5%. Coaches represented 2.40%, and the remaining 97.60% were goalkeepers. The highest participation rate was from the Union of European Football Associations (UEFA) (36.60%), followed by the Asian Football Confederation (AFC) (30.60%); while the lowest contribution was reported from the Oceania Football Confederation (OFC) (2.20%). The participant characteristics are shown in Table 1.

When the participants were asked if they were aware of the FIFA 11+S program, most of them reported «No» (71.70%); while only 28.30% reported that they were aware of it. When evaluating the implementation rate among the minority who were aware of the FIFA 11+S program, it was determined that most participants were implementing it (21.50%) vs. 6.80% of those who were not implementing the FIFA 11+S program. Regarding the opinion of effectiveness of the FIFA 11+S program in preventing shoulder injuries, almost all of the participants consider it as being effective at diverse levels of effectiveness, with the mean (±SD) score of 8.19 (± 0.938).

The obtained results show significant association between both the awareness and implementation and the effectiveness of the FIFA 11+S program. The awareness level did not significantly differ either by gender (because the P value was 0.14) or by the continental football federations; the awareness level was the highest among the participants from UEFA (41.7%) and the lowest among those from OFC (3.4%) (P = 0.33). The data are shown in Table 2.

The continental football federation that reported the highest implementation of the FIFA 11+S program was OFC (37.5%), followed by the Confederation of North, Central American and Caribbean Association Football (CONCACAF) (29.8%); while the lowest implementation rate was reported from the South American Football Confederation (CONMEBOL) (14.6%); however, the difference was not significant. Moreover, the continental football federations did not differ significantly in their opinion regarding the effectiveness of the FIFA 11+S program in preventing shoulder injuries, as shown in Table 2. The implementation level by country is shown in Figure1.

Table 1. Participant Characteristics:

Indicators	Frequency (%)
Continental Football Federations	
AFC	221 (30.6%)
CAF	116 (16.1%)
CONCACAF	57 (7.9%)
CONMEBOL	48 (6.6%)
OFC	16 (2.2%)
UEFA	264 (36.6%)
Gender	
Female	36 (5%)
Male	686 (95%)
Type	
Coach	17 (2.4%)
Goalkeeper	705 (97.6%)
Age groups	
18-25	61 (8.45%)
26-30	616 (85.31%)
31-35	36 (4.99%)
36-40	9 (1.25%)

Asian Football Confederation (AFC); Confederation of African Football (CAF); American and Caribbean Association Football (CONCACAF); South American Football Confederation (CONMEBOL); Oceania Football Confederation (OFC); Union of European Football Associations (UEFA)

Discussion

This cross-sectional survey study was designed to assess goalkeepers' and coaches' awareness and implementation of the FIFA 11+S program and to assess their opinion regarding its effectiveness in preventing shoulder injuries. This study is the first to address this topic. The results of this study revealed that, globally, the awareness level of the FIFA 11+S program among goalkeepers and coaches was poor. However, the implementation rate among aware participants was good, and they rated it as effective in preventing shoulder injuries.

It is known that goalkeepers are more exposed to upper limb injuries than other soccer players (Cohen, Abdalla, Ejnisman, & Amaro, 1997; Terra et al., 2012). In addition, shoulder injuries are more common than other soccer injuries (Hart & Funk, 2015). Therefore, goalkeepers and coaches should be aware of the programs that may help prevent such injuries (e.g., the FIFA 11+S program); however, unexpectedly, the results of this study showed that the majority of

Table 2. Comparison between the continental football federations

Indicators	Continental Football Federations					
	AFC	CAF	CONCACAF	CONMEBOL	OFC	UEFA
	(n = 221)	(n = 116)	(n = 57)	(n = 48)	(n = 16)	(n = 264)
Awareness						
No	165 (74.7%)	89 (76.7%)	39 (68.4%)	37 (77.1%)	9 (56.3%)	179 (67.8%)
Yes	56 (25.3%)	27 (23.3%)	18 (31.6%)	11 (22.9%)	7 (43.8%)	85 (32.2%)
Implementation						
No	19 (8.6%)	5 (4.3%)	1 (1.8%)	4 (8.3%)	1 (6.3%)	19 (7.2%)
Yes	37 (16.7%)	22 (19.0%)	17 (29.8%)	7 (14.6%)	6 (37.5%)	66 (25.0%)
Opinion*						
0	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
1	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
2	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
3	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
4	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
5	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
6	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
7	8 (21.6%)	8 (36.4%)	2 (11.8%)	4 (57.1%)	2 (33.3%)	17 (25.8%)
8	16 (43.2%)	8 (36.4%)	4 (23.5%)	1 (14.3%)	3 (50.0%)	27 (40.9%)
9	11 (29.7%)	3 (13.6%)	5 (29.4%)	0 (0.0%)	1 (16.7%)	20 (30.3%)
10	2 (5.4%)	3 (13.6%)	6 (35.3%)	2 (28.6%)	0 (0.0%)	2 (3.0%)

Asian Football Confederation (AFC); Confederation of African Football (CAF); American and Caribbean Association Football (CONCACAF); South American Football Confederation (CONMEBOL); Oceania Football Confederation (OFC); Union of European Football Associations (UEFA) *10-points scale from 0 (ineffective) to 10 (highly effective).

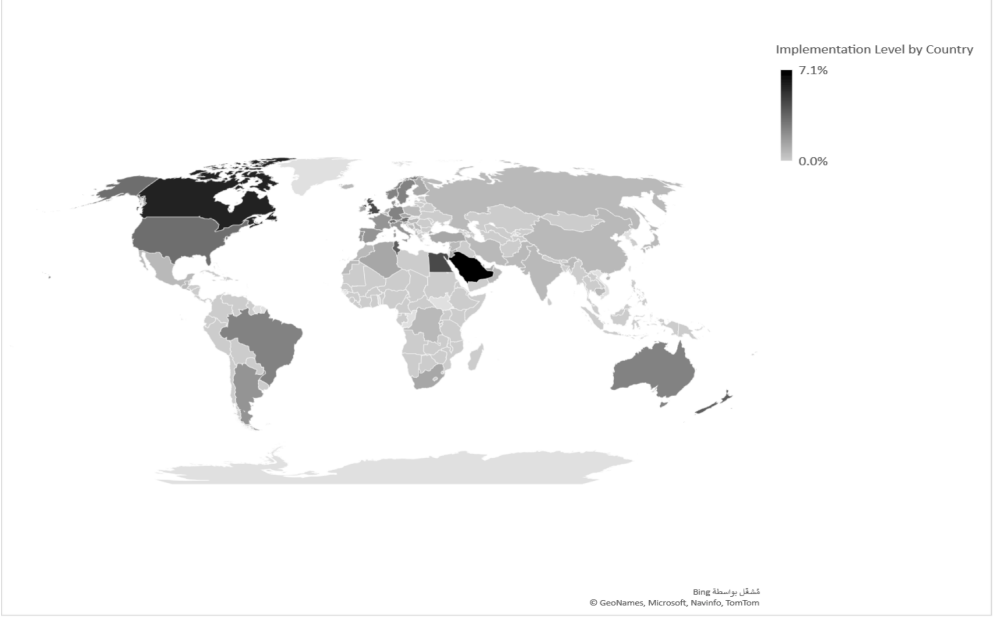

Figure 1. The FIFA 11+ Shoulder Injury Prevention Program implementation level by country

worldwide goalkeepers and coaches were unaware of such programs. However, the lower degree of awareness seems plausible because coaches are the program deliverers (not the goalkeepers), and coaches represented less than 2.5% of the total participants. In addition, the results of this study showed that the level of awareness and implementation was significantly higher among coaches.

Previous studies confirmed the preventive and performance improvement effect of the FIFA 11+ program in female and male amateur soccer players (Bizzini & Dvorak, 2015). Based on this, FIFA 11+S was structured to prevent shoulder injuries. Al Attar et al. (2021) conducted a randomized controlled trial aimed to investigate the FIFA 11+S effectiveness in reducing the incidence of upper extremity injuries, and they determined that FIFA 11+S implementation reduced the upper extremity injury rate among goalkeepers more than usual warm-up training sessions. The results of this study confirm the results of the abovementioned study because most of the participants who implemented this program stated that it was effective.

Regarding the implementation rate, the results of FIFA 11+S seem to agree with those obtained for FIFA 11+, and Al Attar et al. (2018) demonstrated that most of the aware Australian coaches used it. Though most of the aware participants in this current study reported implementing FIFA 11+S, a considerable number did not apply it. Similar incomplete implementation has been also observed in other IPPs (McKay, Steffen, Romiti, Finch, & Emery, 2014; Wilke, Niederer, Vogt, & Banzer, 2018). Unfortunately, this study did not address the reasons for non-usage; however, several factors have been addressed in previous studies including non-availability of equipment, limited space, lack of time, and lack of rated program quality (Joy et al., 2013; McKay, Merrett, & Emery, 2016).

The results of this study highlighted the need for further research. Based on the obtained results, the adherence to FIFA 11+S necessitates both raising awareness among unaware subjects and facilitating usage in aware subjects. Increasing awareness level can be done by improving communication strategies aimed at promoting injury prevention and warm-up programs. For those who are already aware but do not use the program, they might need a more detailed explanation about the program, or they may have difficulties implementing the program that need to be addressed. Inadequate implementation knowledge has been reported to be the major obstacle in delivering the prevention program for anterior cruciate ligament injuries (Joy et al., 2013). Therefore, it is highly recommended that FIFA 11+S contents should be adjusted based on the coaches' educational background.

As with any study, this study has some limitations. The implementation of IPP is a complex process, and the variable 'implement,' which was assessed in this study, is only one facet. In addition to goalkeepers and coaches, who were invited to participate in this study, medical professionals and players are other relevant participants that may affect the success of implementation. Another related aspect to be considered is the questionnaire design. Overall, and based on the obtained data, further research should aim to define and allocate several factors that contribute to concepts such as program usage, feasibility, or suitability. Despite these limitations, the data were collected from different continental football federations; therefore, the results can be generalized globally.

Conclusions

This study is the first to investigate goalkeepers' and coaches' awareness, implementation, and opinion of the effectiveness of the FIFA 11+S program in reducing shoulder injuries globally. Overall, the awareness rate was exceptionally low, but the implementation level among aware participants was good. Goalkeepers and coaches attained a positive score regarding the FIFA 11+S effectiveness in reducing shoulder injuries. Further efforts and research are needed to increase the awareness and usage of the FIFA 11+S program.

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Conflict of interest

The authors declared no conflicts of interest.

References

Tomlinson, A. (2014). *FIFA (Fédération internationale de football association): the men, the myths and the money: Routledge.*

Longo, U. G., Loppini, M., Berton, A., Martinelli, N., Maffulli, N., & Denaro, V. (2012). Shoulder injuries in soccer players. *Clin. Cases Miner. Bone Metab, 9*(3), 138-141.

Ejnisman, B., Barbosa, G., Andreoli, C. V., de Castro Pochini, A., Lobo, T., Zogaib, R., . . . Dvorak, J. (2016). Shoulder injuries in soccer goalkeepers: Review and development of a FIFA 11+ shoulder injury prevention program. *Open Access J of Sports Med,* 7, 75-80. https://doi.org/10.2147/OAJSM.S97917

Al Attar, W.S.A., Faude, O., Bizzini, M., Alarifi, S., Alzahrani, H., Almalki, R.S., Banjar, R.G., Sanders, R.H. (2021). The FIFA 11+ Shoulder Injury Prevention Program Was Effective in Reducing Upper Extremity Injuries Among Soccer Goalkeepers: A Randomized Controlled Trial. *Am. J. Sports Med.* https://doi.org/10.1177/03635465211021828

Cools, A. M., Johansson, F. R., Borms, D., & Maenhout, A. (2015). Prevention of shoulder injuries in overhead athletes: A science-based approach. *Braz. J. Phys. Ther, 19*(5), 331-339. https://doi.org/10.1590/bjpt-rbf.2014.0109

Asker, M., Brooke, H. L., Waldén, M., Tranaeus, U., Johansson, F., Skillgate, E., & Holm, L. W. (2018). Risk factors for, and prevention of, shoulder injuries in overhead sports: A systematic review with best-evidence synthesis. *Br J Sports Med, 52*(20), 1312-1319. https://doi.org/10.1136/bjsports-2017-098254

Al Attar, W.S.A., Soomro, N., Pappas, E., Sinclair, P. J., & Sanders, R. H. (2016). How effective are F-MARC injury prevention programs for soccer players? A systematic

review and meta-analysis. *Sports Med, 46*(2), 205-217. https://doi.org/10.1007/s40279-015-0404-x

Cohen, M., Abdalla, R. J., Ejnisman, B., & Amaro, J. T. (1997). Lesões ortopédicas no futebol [Orthopedic injuries in football]. *Rev. Bras. Ortop, 32*(12), 940-944.

Terra, B., Ejnisman, B., Figueiredo, E., Andreoli, C., Pochini, A., Cohen, C., Cohen, M. (2012). Arthroscopic treatment of glenohumeral instability in soccer goalkeepers. *Int. J. Sports Med, 34*(06), 473-476. https://doi.org/10.1055/s-0032-1327656

Hart, D., & Funk, L. (2015). Serious shoulder injuries in professional soccer: Return to participation after surgery. *Knee Surgery, Sport TR A, 23*(7), 2123-2129. https://doi.org/10.1007/s00167-013-2796-1

Bizzini, M., & Dvorak, J. (2015). FIFA 11+: An effective programme to prevent football injuries in various player groups worldwide-a narrative review. *Br J Sports Med, 49*(9), 577-579. https://doi.org/10.1136/bjsports-2015-094765

Al Attar, W.S.A., Soomro, N., Sinclair, P. J., Pappas, E., Muaidi, Q. I., & Sanders, R. H. (2018). Implementation of an evidence-based injury prevention program in professional and semi-professional soccer. *Int J Sports Sci Coach, 13*(1), 113-121. https://doi.org/10.1177/1747954117707482

McKay, C. D., Steffen, K., Romiti, M., Finch, C. F., & Emery, C. A. (2014). The effect of coach and player injury knowledge, attitudes and beliefs on adherence to the FIFA 11+ programme in female youth soccer. *Br J Sports Med, 48*(17), 1281-1286. https://doi.org/10.1136/bjsports-2014-093543

Wilke, J., Niederer, D., Vogt, L., & Banzer, W. (2018). Is the message getting through? Awareness and use of the 11+ injury prevention programme in amateur level football clubs. *PLoS One, 13*(4), e0195998. https://doi.org/10.1371/journal.pone.0195998

Joy, E. A., Taylor, J. R., Novak, M. A., Chen, M., Fink, B. P., & Porucznik, C. A. (2013). Factors influencing the implementation of anterior cruciate ligament injury prevention strategies by girls soccer coaches. *J. Strength Cond. Res, 27*(8), 2263-2269. https://doi.org/10.1519/jsc.0b013e31827ef12e

McKay, C. D., Merrett, C. K., & Emery, C. A. (2016). Predictors of FIFA 11+ implementation intention in female adolescent soccer: An application of the health action process approach (HAPA) model. *Int. J. Environ. Res. Public Health, 13*(7), 657. https://doi.org/10.3390/ijerph13070657

ОБМЕЖЕНЕ ВПРОВАДЖЕННЯ ПРОГРАМИ ПРОФІЛАКТИКИ ТРАВМ ПЛЕЧЕЙ FIFA 11+ (FIFA 11+ S) СЕРЕД ПРОФЕСІЙНИХ ФУТБОЛЬНИХ ВОРОТАРІВ

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Реферат. Стаття: 7 с., 2 табл., 1 рис., 16 джерел.

Мета дослідження. Футбол є одним з найпопулярніших видів спорту в усьому світі. Футбольні воротарі частіше, ніж польові гравці, травмують свої верхні кінцівки, зокрема плечі. Програма профілактики травм плечей 11+ Міжнародної федерації футболу (FIFA) була розроблена для запобігання травмам верхніх кінцівок. Дане дослідження мало на меті оцінити обізнаність, рівень впровадження та думку футбольних воротарів та їх тренерів щодо ефективності FIFA 11+S у зменшенні травм верхніх кінцівок.

Матеріали і методи. Було розроблено опитувальник для самостійного заповнення та розповсюджено серед професійних футбольних воротарів та тренерів воротарів у всьому світі. Опитування було доступне 10 різними мовами. Анкета складалася з питань, що охоплювали обізнаність, впровадження та думку воротарів та тренерів воротарів щодо Програми профілактики травм плечей FIFA 11+ у зменшенні травм верхніх кінцівок. Розробкою питань керували кілька авторів, спеціалістів зі спортивної медицини та програм профілактики травм.

Результати. Всього в опитуванні взяли участь 722 воротарі та тренери воротарів. Переважну більшість (97,60%) учасників складали воротарі. Лише 204 (28,25%) учасники знали про існування FIFA 11+S, а 155 (21,46%) впроваджували FIFA 11+S у своїй поточній практиці. Учасники, які застосовували FIFA 11+S, дали позитивний відгук про ефективність програми з оцінкою 8,19 ± 0,93 з 10.

Висновки. Це дослідження є першим, у якому досліджується обізнаність, рівень впровадження та думка

воротарів і тренерів щодо ефективності програми FIFA 11+S у зменшенні травм плечей у всьому світі. Загалом рівень обізнаності був надзвичайно низьким, але рівень впровадження серед обізнаних учасників був хорошим. Воротарі та тренери дали позитивну оцінку щодо ефективності FIFA 11+S у зменшенні травм плечей. Необхідні подальші зусилля та дослідження для підвищення обізнаності та рівня використання програми FIFA 11+S.

Ключові слова: футбол, травма плеча, верхня кінцівка, опитування, анкетування.

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ORIGINAL SCIENTIFIC ARTICLE

EFFECT OF VINYASA TRAINING ON DYNAMIC BODY BALANCE OF MALE NATIONAL LEVEL YOGA PLAYERS

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

Background. Body balance is among the most important aspects for achieving athletic excellence in competitive sports. Body balance helps in the development of proper body posture control, which supports high performance and skill demonstration across all sports. Body balance is known to be positively correlated to competitive athletic performance. In sports, good balance implies moving more efficiently and with better body control. Yoga is one of the means of improving body balance, and it has also been linked to enhancing athletic performance. Vinyasa yoga is a powerful method that targets the entire body. Navigate challenging poses to improve your strength, flexibility, and balance, especially if you want to target muscle groups that aren't used in your preferred sport.

The focus of this study. To analyse the efficacy of a 6-week Vinyasa Yoga Training Programme (VYTP) in improving dynamic body balance of male national level yoga players.

Materials and methods. Twenty male national level yoga players (18-25 years) from the Lakshmibai National Institute of Physical Education, Gwalior, India, participated in the study. The participants were then randomly allocated into two groups, one experimental (Vinyasa) and the other control. The Sensbalance machine was used to measure the dynamic body balance.

Results. ANCOVA indicates a significant difference in the selected variable of dynamic body balance in the experimental group compared to the control group. When compared to the control group which did not receive any training, the post-test found that the experimental yoga group significantly improved in dynamic body balance.

Conclusions. VTYP was found to be helpful in enhancing dynamic body balance. In the current study after six weeks of vinyasa training it was observed that the male national yoga players had a substantial difference in dynamic body balance compared to the control group.

Keywords: yoga, vinyasa, VTYP, dynamic body balance, competitive sports.

Introduction

Competitive sporting life requires an optimum level of body balance for better athletic performance. Balance (postural control) is the ability to maintain the vertical position of the body's center of gravity while undertaking coordinated and precise neuromuscular activity to execute a task (Hrysomallis, 2011). Athletes concentrate their training mainly on objectives: gaining better control over bodily posture, avoiding injury, and improving performance. In competitions, balance training has been widely required to enhance balance and thereby minimize the possibility of injury, such as ligamentous sprains, which are highly common in sports (Saraswat, 2015). There are basically two type of balance in sports to look at equilibrium - static and dynamic balance. Static balance (e.g., headstand) is described as the ability to maintain a stable base of support with minimal movement (Bressel et al., 2007), Static balance is a critical component contributes to effective performance, particularly in sports which demands higher bodily postural control (Rogers en al., 2013). Many experts have inferred that static equilibrium is a factor for balance control and suggested for players since it not only improves sports performance but also decreases lower extremity damage (Boccolini et al., 2013).

Dynamic balance is the ability of the body (e.g., somersault in gymnastics) to maintain a body's center of mass while performing the combination of complex movements

(Brown & Weir, 2001). Studies have shown that dynamic balance and postural control are essential for success in all competitive sports (Cote et al., 2005; Erkmen et al., 2007). Improving dynamic balance has been found to greater agility, faster reaction times, and overall performance for athletes and helps to reduce the risk of acute and chronic injuries, and overall coordination of the muscle groups in executing an activity (Brachman et al., 2017).

One of the ways to achieve optimal functioning dynamic body balance in athletic performance is to practice Yoga. Yoga is derived from the Sanskrit word "Yuj"("युज"), which refers to the unification of individual and universal consciousness (Singh, 2018). Maharshi Patanjali, refers Yoga as «Yogaschitta vrtti nirodhah,» which means Yoga is a state of mind that is in balance without any fluctuations in mind (Saraswati, 2016). Various types of yoga may have different goals in terms of focus, mindfulness, and muscular engagement. While Hatha yoga focuses on focused breathing methods, flexibility, and meditation, Vinyasa yoga focuses on muscular endurance (Sharma, 2018).

Vinyasa yoga is a yoga method that consists on putting postures together so that one can flow from one to the next posture with breath awareness (Ramaswami, 2005). Vinyasa as a philosophy, acknowledges the impermanent nature of things, it originally referred to a series, or sequence of steps, to make something sacred with a stable stance taken up, hold it for a few moments, and then release it (Saal, 2019). Vinyasa yoga is one type of Yoga, that can aid in improving dynamic balance in competitive sports. Many studies has investigated that yoga practice aids in the improvement of various physical and psychological dimensions to be precise. Research revealed that yoga exercises are useful in developing balance and perception (Rayat, 2015). The findings imply that a regular yoga practice can improve male college players' balance and flexibility and so improves athletic performance (Polsgrove et al., 2016). Previous investigations states that vinyasa is a cost-effective and alternative training method, it can improve fitness and boost overall wellness (Tsopanidou et al., 2020). Positive improvement has been found in yoga training programme on balance, flexibility and strength of male soccer players (Kartal & Ergin, 2020). In a study, following six months of vinyasa training, females had changes in maximal muscle torque, as well as alterations in muscle topography (Buśko & Rychlik, 2006). Long-term vinyasa yoga-based programmes have shown enhancement in health related fitness condition significantly (Boraczyński et al., 2020). Despite the desirable findings of the studies, however, no previous studies have investigated on the short-term (6 weeks) effects of Vinyasa Yoga Training Programme (VYTP), as well as research on dynamic body balance.

The focus of the present study was to examine the effect of a short term six-week VYTP on dynamic body balance of male national level yoga players.

Materials and methods

Study participants

Twenty male national level participants (aged 18-25 years) with prior yoga experience (but without previous structured vinyasa training experience) consent for this study from Lakshmibai National Institute of Physical Education in Gwalior, India. Participants were allocated into experimental (vinyasa training) group and control (daily schedule) group. Ethical approval was obtained prior to the study.

Study organization

VYTP in this study consisted of 5 different batteries of various bodily yogic postures mainly Surya Namaskar, Standing Vinyasa Series, Plank Vinyasa Series, Proline Vinyasa Series and Supine Vinyasa Series, as displayed in Table1. On the other hand, Table 2 explaining with a micro-cycle example about Vinyasa Training program 5 Days a Week.

Sensbalance was utilised as the study's tool for data collection purpose. Sensbalance is a completely computerised system machine that is designed for improving balance (static and dynamic), increase body awareness and coordination abilities. The angle of maximum tilt was set at 15o in all directions and time duration was set 30 seconds. During this test, the person moved the platform and gazed at the computer screen to track the reference location produced by

Table 1. Six Weeks Vinyasa Programme

S. No.	Test Battery	Postures/Asanas
1	Warmup +Prayer	Active Stretching+ Yogic Prayers
2	Surya Namaskar	12 Postures
3	Standing Vinyasa Series	Awkward chair Goddess pose Awkward chair Goddess pose Awkward chair Standing forward bend Standing high lunge Pyramid Standing stretch (Tadasana) Tree pose Single leg awkward chair
4	Plank Vinyasa Series	Pushup plank Plank Side plank Four limbed staff One leg raise plank Cross side leg plank
5	Proline Vinyasa Series	Sarpasana Upward facing dog(bhujangasna) Single leg salbhasana Both leg salbhasana Reverse boat Single leg bow pose Both leg bow pose
6	Supine Vinyasa Series	Bridge Single leg bridge Side leg bridge Chakrasana Reverse plank
7	Relaxation	Yogic Nidra

Note. Style Adapted from Unpublished thesis LNIPE, Gwalior., by Singh. V, 2019, p. 18.

the movement of the circle on the computer screen. The participants were required to balance over a single leg throughout the test. The test results were produced by the computer when the test time finished.

Procedure

Two sessions were held prior to the start of the VYTP to familiarise the participants about the data collection, VYTP procedures and test protocol. The training intervention lasted 6 weeks and consisted of 30-minute training sessions (Table 1 & Table 2). One micro-cycle lasted 7 days and included 5 training sessions (Monday-Friday) under the supervision and guidance of the first author. Training data was collected at two specific intervals: week 1 (before training) and weeks 6 (after training).

Statistical analysis

In this study, IBM SPSS (version 20) software was used to run ANCOVA analyses to examine the data.

Results

ANCOVA (in Table 3), showing the descriptive statistics information of experimental and control group male national yoga player about dependent variable: dynamic body balance after training. The experimental group had mean and standard deviation of 75.60 ± 3.27, and the control group had mean and standard deviation of 70.50 ± 2.50 respectively.

Table 3. Descriptive Statistics Dependent Variable: Dynamic Body Balance After Training

Group	Mean	Std. Deviation	N
Experimental	75.600	3.272	10
Control	70.500	2.505	10
Total	73.050	3.859	20

The statistical significance level was set at $p \leq 0.05$. The p-value linked with the F-statistics for leg strength is 0.004, which is less than 0.05 (Table 4), results from ANCOVA found a significant difference in the selected variable dynamic body balance in the experimental group compared to the control group. When compared to the control group which did not received any training, the post-test found that the experimental yoga group significantly improved in dynamic body balance.

As a result, when the dynamic body balance of male national level yoga players was compared to the dynamic body balance of the control group, the experimental group had a substantial improvement.

Discussion

The study aimed to evaluate the effect of "six weeks vinyasa training on dynamic body balance of male national level yoga players". The VYTP included a well-structured battery of combination of five series of vinyasa yoga posture, it was conducted for six weeks, five days a week and a session of 30 min each. The study resulted that the experimental group showed significantly better improvement in the dynamic body balance, revealing that the VYTP was effective. According to the findings in the current study, VYTP is helpful in generating significantly positive improvements in dynamic body balance. The very study also shows that the five-day-a-week vinyasa yoga practice may have provided enough stimuli to improve dynamic body balance of yoga players. It is worth mentioning that even a 6-week intervention was adequate to improve dynamic body balance.

Table 4. ANCOVA Table Dependent Variable: Dynamic Body Balance After Training

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Pre-test	73.803	1	73.803	15.862	.001
Groups	49.853	1	49.853	10.715	.004
Error	79.097	17	4.653		
Corrected Total	282.950	19			

Note. a. R Squared = .720 (Adjusted R Squared = .688) b. Computed using alpha = .05

Furthermore, we know that past studies have found that a yoga intervention improves adolescence balance, flexibility, and strength (Fillmore et al., 2010). The findings imply that a regular yoga practice can improve male college players' balance and flexibility, as well as whole body measurements, and so improve athletic performance (Polsgrove et al., 2016). Previous researches also revealed effectiveness of long-term vinyasa yoga-based programmes helped in improving health-related fitness condition significantly. The use of cumulative target heart rate targets resulted in greater than predicted gains in cardio-respiratory fitness and body composition (Boraczyński et al., 2020). Vinyasa is an alternative training method it can increase overall fitness and boost wellness (Tsopanidou et al., 2020). In a study, following six months of Vinyasa instruction, changes found in maximal muscle torque, as well as alterations in muscle topography (Buśko & Rychlik, 2006), regular exercise programmes with resistance training and yoga training, can help people with multiple sclerosis improve their lower limb strength and balance (Hosseini et al., 2018). The analysing of data in another study revealed that yoga exercises are useful in developing balance and perception (Rayat, 2015). It was found that the 6-week yoga programme improved balance, flexibility and strength of male soccer players thus coaches must implement it in the training before the competitive season since they will help soccer players enhance their overall motor skills (Kartal & Ergin, 2020). Evidently, these findings strongly support present study of short term yogic intervention on sports performance enhancement.

One of the potential limitations of the study that may have affected the results could have been its limited sample size, this study was focused at one gender (male), one sport (yoga), and level of players (national-yoga), which may have affect its generalizability. Another study potential limitation was that the subjects' lifestyle, routine, eating habits, and socioeconomic background may have influenced the findings.

Over the due course of time, it is observed that this study performs well as a pilot study, implying the possibility

of a larger investigation. According to the findings, future research is needed to see how well vinyasa yoga meets the needs of other various population subgroups (e.g., eating disordered, overweight/obese, sedentary, and smokers). Future studies should focus on different time intervals, and researchers could use comparable studies to address diverse groups of players from different sports and genders. Other areas of future research should focus on vinyasa effect on physiological aspects such as oxygen consumption changes, metabolic analysis and energy expenditure during different paces of vinyasa and time intervals. Postural practices, meditative forms such as tai-chi, and other types of yoga such as hatha and ashtanga can also be worked up to determine if they enhance other skill and fitness related physical components such as static equilibrium, which is equally vital in sports.

According to the findings of the study, vinyasa yoga could be beneficial for improving balance, reducing the chances of injuries in competitive sports, eventually assisting to enhance the performance. Coaches and teachers could use vinyasa in training programmes since it will contribute in the development of static body balance of the players.

Conclusion

In competitive sports, dynamic body balance is essential, and vinyasa yoga can help in improving dynamic body balance. According to this study, VTYP was found to be helpful in enhancing dynamic body balance. In the current study after six weeks vinyasa training it was observed that the male national yoga players had a substantial difference in dynamic body balance compared to control group. To conclude, coaches can incorporate the vinyasa training programme as an alternative to their training programme to increase dynamic balance and athlete performance in competitive sports.

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Conflict of interest

Authors have no conflict of interest to disclose.

References

Hrysomallis, C. (2011). balance ability and athletic performance. *Sports Medicine,* 41, 221-232. https://doi.org/10.2165/11538560-000000000-00000

Saraswati, S. S. (2016). Four chapters on freedom-commentary on the yoga sutras of sage patanjali. Yoga Publications Trust; First digital edition.

Bressel, E., Yonker, J. C., Kras, J., & Heath, E. M. (2007). Comparison of static and dynamic balance in female collegiate soccer, basketball, and gymnastics athletes. *Journal of Athletic Training, 42*(1), 42-6. PMID: 17597942

Rogers, M. E., Page, P., & Takeshima, N. (2013). Balance training for the older athlete. *International journal of sports physical therapy, 8*(4), 517-530. PMID: 24175135

Boccolini, G., Brazzit, A., Bonfanti, L., & Alberti, G. (2013). Using balance training to improve the performance of youth basketball players. *Sport Sciences for Health, 9*(2), 37-42. http://doi.org/10.1007/s11332-013-0143-z

Brown, L. E. & Weir, J. P. (2001). ASEP procedures recommendation I: Accurate assessment of muscular strength and power. *Journal of Exercise Physiology Online, 4*(3), 1- 21.

Cote, K .P., Brunet, M.E., Gansneder, B. M., & Shultz, S. J. (2005). Effects of pronated and supinated foot postures on static and dynamic postural stability. *Journal of Athletic Training, 40*(1), 41-46. https://doi.org/10.37506/ijpot.v15i1.13355

Erkmen, N., Suveren, S., Göktepe, A. S. & Yazıcıoğlu, K. (2007). The comparison of balance performance of the athletes who are in different branches. *Spormetre, 5*(3), 115-122. http://doi.org/10.1501/Sporm_0000000080

Brachman, A., Kamieniarz, A., Michalska, J., Pawłowski, M., Słomka, K. J., & Juras, G. (2017). Balance training programs in athletes: A systematic review. *Journal of human kinetics,* 58, 45-64. https://doi.org/10.1515/hukin-2017-0088

Singh, V. (2018). Comparative study of teaching methods between traditional and modern yoga. International conference on relevance and utility of yoga education in present scenario. *International Journal of Research Culture Society, Special Issue,* (9), 37-40.

Sharma, Y. C., Sharma, S. & Sharma, E. (2018). Scientific benefits of Yoga: A Review. *Research Review International Journal of Multidisciplinary, 3*(8), 144-148. https://doi.org/10.5281/zenodo.1341773

Ramaswami, S. (2005). *The complete book of vinyasa yoga. da capo press*. https://www.pdfdrive.com/the-complete-book-of-vinyasa-yoga-complete-d33437381.html

Saal, K. (2019, February 19). *What is Vinyasa Yoga? One Flow Yoga.* https://oneflowyoga.com/blog/what-is-vinyasa-yoga

Rayat, S. (2015). effect of practice of yoga exercises on balance and perception of national level players. *Journal of Sports and Physical Education, 2*(4), 25-30. http://doi.org/10.9790/6737-0242530

Polsgrove, M. P., Eggleston, B. M., & Lockyer, R. J. (2016). Impact of 10-weeks of yoga practice on flexibility and balance of college athletes. *International journal of Yoga, 9*(1), 27-34. http://doi.org/10.4103/0973-6131.171710

Tsopanidou, A. A., Venetsanou, F. D., Stavridis, I. S., Paradisis, G. P. & Zacharogiannis, E. G. (2020). Energy expenditure during a Vinyasa yoga session. *The Journal of Sports Medicine and Physical Fitness, 60*(8), 1110-1117. http://doi.org/10.23736/S0022-4707.20.10821-1

Kartal, A., & Ergin, E. (2020). Investigation of the effect of 6-week yoga exercises on balance, flexibility, and strength in soccer players. *International Journal of Human Movement and Sports Sciences, 8*(3), 91-96. https://doi.org/10.13189/saj.2020.080303

Buśko, K., & Rychlik, R. (2006). Changes of the maximal muscle torque in females. *Human Movement, 7*(2), 168-177.

Boraczyński, M.T., Boraczyński, T.W., Wójcik, Z., Gajewski, J., & Laskin, J. J. (2020). The effects of a 6-month moderate-

intensity hatha yoga-based training program on health-related fitness in middle-aged sedentary women: a randomized controlled study. *The Journal of Sports Medicine and Physical Fitness, 60*(8), 1148-1158. http://doi.org/10.23736/S0022-4707.20.10549-8

Fillmore, B. D., Brahler, C., Fisher, M. I., & Beasley, K. (2010). The effect of yoga postures on balance, flexibility, and strength in healthy high school females. *Journal of Women's Health Physical Therapy, 34*(1), 10-17. http://doi.org/10.1097/JWH.0b013e3181d4fe51

Hosseini, S. S., Rajabi, H., Sahraian, M. A., Moradi, M., Mehri, K., & Abolhasani, M. (2018). Effects of 8-week home-based yoga and resistance training on muscle strength, functional capacity and balance in patients with multiple sclerosis: A randomized controlled study. *Asian Journal of Sports Medicine 9*(3):e68807. http://doi.org/10.5812/asjsm.68807

ВПЛИВ ТРЕНУВАННЯ ВІН'ЯСА НА ДИНАМІЧНУ РІВНОВАГУ ТІЛА СПОРТСМЕНІВ-ЧОЛОВІКІВ, ЯКІ ЗАЙМАЮТЬСЯ ЙОГОЮ НА НАЦІОНАЛЬНОМУ РІВНІ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 4 табл., 21 джерел.

Проблематика. Рівновага тіла є одним із найважливіших аспектів для досягнення атлетичної майстерності у змагальних видах спорту. Рівновага тіла допомагає у розвитку правильного контролю постави, що сприяє високим досягненням та демонстрації навичок у всіх видах спорту. Відомо, що рівновага тіла позитивно корелює з конкурентоспроможними спортивними здібностями. У спорті хороша рівновага передбачає більш ефективний рух і кращий контроль над тілом. Йога є одним із засобів для покращення рівноваги тіла та підвищення спортивних результатів. Він'яса-йога — це потужний метод, націлений на розвиток всього тіла. Виконуйте складні пози, щоб покращити свою силу, гнучкість та рівновагу, особливо якщо ви хочете розвинути групи м'язів, які не задіяні у вашому основному виді спорту.

Мета дослідження – проаналізувати ефективність 6-тижневої тренувальної програми Він'яса-йоги (ТПВЙ) у покращенні динамічної рівноваги тіла спортсменів-чоловіків, які займаються йогою на національному рівні.

Матеріали і методи. Учасниками дослідження були двадцять спортсменів-чоловіків, які займаються йогою на національному рівні (18-25 років), з Національного інституту фізичного виховання імені Лакшмі Бай, Гваліор, Індія. Учасників випадковим чином було розділено на дві групи: експериментальну (він'яса) і контрольну. Для вимірювання динамічної рівноваги тіла використовувався прилад Sensbalance.

Результати. Коваріаційний аналіз вказує на значну різницю у вибраній змінній динамічної рівноваги тіла в експериментальній групі порівняно з контрольною групою. У порівнянні з контрольною групою, яка не проходила жодного тренування, підсумковий тест показав, що експериментальна група з йоги значно покращила динамічну рівновагу тіла.

Висновки. Було виявлено, що ТПВЙ допомагає покращити динамічну рівновагу тіла. Дане дослідження показало, що після шести тижнів тренування він'яса спортсмени-чоловіки, які займаються йогою на національному рівні, мали істотну різницю в динамічній рівновазі тіла порівняно з контрольною групою.

Ключові слова: йога, він'яса, ТПВЙ, динамічна рівновага тіла, змагальні види спорту.

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ORIGINAL SCIENTIFIC ARTICLE

CARDIORESPIRATORY FITNESS CUT-POINTS RELATED TO BODY ADIPOSITY PARAMETERS IN MACEDONIAN CHILDREN

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Abstract

Background and Objectives: There is a shortage of criteria referent standards for tests of logistic application meant to estimate the cardiorespiratory fitness (CRF) of children and adolescents in the Republic of North Macedonia. The goal of the research was twofold: (1) To identify the ability of CRF estimated by the 20-m shuttle-run test (20mSRT) to discriminate between "healthy" and "unhealthy" phenotypes (by adiposity measures such as WC and WHR) in children; (2) To determine the correlation between obesity and relatively maximum oxygen consumption (VO_2 peak) tested on a relatively large respondents' sample of Macedonian children. The research was conducted on a sample of 1,863 respondents, 957 (51.4%) of whom were boys, and 906 (48.6%) were girls at the age of 7 to 10 years. All of them were from 19 primary schools in the central and eastern parts of the Republic of North Macedonia.

Materials and Methods: The waist circumference (WC) and waist-to-height ratio (WHtR) were used to identify body adiposity markers. CRF was measured using the 20mSRT (VO_2 peak). Receiver operating characteristic curves and logistic regression were applied in order to establish the discriminative power of CRF in anticipating the parameters of body adiposity markers.

Results: With regard both to the boys and girls, VO_2 peak showed considerable predictive power of identifying the body adiposity (area under the curve [AUC] > 0.66). In boys, when considering the full sample (7-10 years), the best cut-point for VO_2 peak to detect body fat by WC were 48.8 to $mL \cdot kg^{-1} \cdot min^{-1}$ and WHtR were 47.4 to $mL \cdot kg^{-1} \cdot min^{-1}$. For girls, when considering the full sample (7-10 years), the best cut-point to detect body fat by WC were 47.4 to $mL \cdot kg^{-1} \cdot min^{-1}$ and WHtR were 47.1 to $mL \cdot kg^{-1} \cdot min^{-1}$.

Conclusions: According to these cut-points, adolescents with low CRF were more likely to be obese either by WC or WHtR. The border values (cut-points) of CRF can be used as quantitative markers of children of healthier body characteristics from the Republic of North Macedonia.

Keywords: epidemiology, obesity, weight status, children, adolescents.

Introduction

The lack of physical activity, and the low level of cardiorespiratory fitness (CRF) are a huge threat for the public health. Yet their prevailing number is rapidly increasing in countries of development, as is generally the case with Macedonian children and adolescents (Gontarev & Kalac, 2016; Gontarev et al., 2016; Gontarev et al., 2018). Along with that, those of the children suffering from obesity and fat are very likely to remain overweight persons up to their mature age, and there is a greater possibility for them to develop some metabolic risks during their younger age (Sahoo et al., 2015). Although the clinical manifestations of many chronic disease are chiefly displayed in the mature age, it is well known that the long asymptomatic phase of development has its roots early in a person's life, often in their childhood

(Balagopal et al., 2011), which indicates that the initiative of chronic disease prevention should begin within the years of that period of life.

The cardio-respiratory fitness is an equally powerful predicator of a mortal risk, just as the traditional risk factors such as smoking, obesity, hypertension, dyslipidemia and type 2 diabetes mellitus both with children, adolescents and aged population (Kaminsky et al., 2019). A considerable number of research works emphasize the relation between the low level of cardio-respiratory fitness and adiposity with a great risk of cardio-metabolic diseases among the young (Mintjens et al., 2018). In response, the fitness and health outcomes in youth assessment guidelines have called for a better understanding of the close relation between the components of fitness and body composition (Pillsbury, Oria & Pate, 2013). In this sense, the mutual relation of the increased adiposity with a lower level of cardio-respiratory fitness is generally the strongest when adiposity is measured by imagining techniques; it is somewhat weaker when it is assessed by using WC and WHtR, and the weakest when the body mass index (BMI) is used (Lee & Arslanian, 2007).

Despite that the physical fitness and body adiposity can be correlated, they are not markers of different diseases' risks. It is established in a certain number of studies, which have been conducted on young population, that those of the youngsters who have a low level of adiposity and low level of cardio-respiratory fitness are subjected to a higher cardiovascular risk than those of the young persons who though have greater adiposity but at the same time have an adequate level of cardio-respiratory fitness, regardless their muscular fitness and body composition (Grøntved et al., 2015; Silva et al., 2018). Recently, Silva et al. (2018) have established that the results obtained from the 20-m shuttle run test, which was applied to Canadian children at the age from 8 to 12 years, were correct so that the sample could be classified according to the fat indicator in relation to the CRF level. In the present study, when using sex-specific cut-points, it was found that regardless of the 20mSRT indicator (laps, VO_2peak or speed), those children having less of the recommended values face a greater possibility to become obese, either by WC, BMI, or both, regardless the factors as the age, the time spent on electronic devises, and the level of physical activity. These results confirm the results obtained in other research works which have established that the cardio-respiratory fitness is independent of the factor of obesity risk and increases the necessity of development of CRF health-related standards in order to predict the cardio-metabolic health of young people. According to that, the comparison of the differences in the criteria referent standards of different predicative equality that are used for assessing the aerobic capacity will help to identify different phenotype risks (optimal and poor health) from the CRF levels estimated by 20mSRT performance and will be of significant public health value. Apart from the fact that there are criterion-referenced cut-points in many countries of high economic development, there is only one study conducted in the R. N. Macedonia (Pireva et al., 2018).

The instructions of estimating the fitness activity of the young population suggest of better understanding of the mutual correlation between the physical fitness and body composition (Pillsbury, Oria & Pate, 2013). Therefore, the defining of the criterion-referenced cut-points connected with the body adiposity parameters in children and adolescents can be useful in identifying the target population for prevention of primary chronic diseases, as well as for creating national politics for promotion of health. The goals of the present research were twofold: (1) To identify the ability of CRF estimated by the 20mSRT to discriminate between "healthy" and "unhealthy" phenotypes (by adiposity measures such as WC and WHR) in children; (2) to establish the connection between the obesity and relative maximum oxygen consumption (VO_2peak) on a relatively big sample of Macedonian children.

Materials and Methods

Participants

The research was conducted on a sample of 1863 children from 19 primary schools in the central and eastern part of the Republic of North Macedonia, of which 8 are located in rural and 11 in urban areas. The sample was divided into two subsamples by gender: 957 respondents were boys and 906 respondents were girls. The average age of the respondents was 8,98±2,37 years. The study included all students whose parents agreed to participate in the study, who were psychophysically healthy, and who regularly attended physical and health education classes. The respondents were treated in accordance with the Helsinki Declaration of 1961 (revision of Edinburgh 2013). The protocols were approved by the Ethics Committee at the University "St. Cyril and Methodius" in Skopje.

The measurements were carried out in March, April and May 2019 in standard school conditions at regular physical and health education classes. The measurements were performed by kinesiology and medicine experts, previously trained in performing functional tests and taking anthropometric measures.

Body Adiposity Parameters

The measurements of weight, height, and WC were carried out at school applying standardized procedures; all the instruments were verified before measuring each subject. Weight was measured in underwear and without shoes with an medical decimal weight scales, to the-nearest 0.1 kg, and height was measured barefoot in the Frankfort horizontal plane with a telescopic height measuring instrument (Martin's anthropometry) to the nearest 0.1 cm. Body mass index was calculated as bodyweight in kilograms divided by the square of height in meters. Waist circumferences were measured twice using inextensible anthropometric tape with the children standing erect and relaxed, with arms at the sides and feet positioned close together. Waist circumference was measured midway between the lowest border of the rib cage and the upper border of the iliac crest, at the end of normal expiration (de Oliveira & Guedes, 2018) WC and height were used to calculate WHtR, with obesity defined as ≥0.50 according to previous reports (Schwandt & Haas, 2016). The 75th percentile of WC according to age and gender were determined based on data collected from the de Ferranti et al. (de Ferranti et al., 2004). WC and WHtR have been used as proxies for central (visceral) adipose tissue which has recently received attention as a marker of 'early health risk' in many populations (Ashwell & Gibson, 2016).

Cardiorespiratory Fitness (CRF)

The 20 meter shuttle run test (Leger et al., 1988) was used to measure fitness. All testing was completed on a firm and level surface (concrete play area at each school). For this test, children were required to run back and forth between two lines placed 20 meters apart. A sound signal was emitted from a pre-recorded tape to dictate running speed. Frequency of the sound signals increased such that running speed increased by 0.5 km/hour each minute from the starting speed of 8.5 km/hour. The test ended when children could no longer keep pace with the sound signal. The last stage that children reached was used to predict maximal oxygen uptake (VO_2max) from the running speed corresponding to that stage (VO_2max = 31.025 + 3.238 X – 3.248 A + 0.1536, where X = the final speed and A = age). This test showed good to very good repeatability and validity (Ramírez-Vélez et al., 2015).

Statistical Analysis

The basic statistical parameters (arithmetic mean, standard deviation, frequency) were calculated for all variables. The normal distribution of all variables was controlled by Kolmogorov-Smirnov method. None required transformation due to normally distributed. In order to establish the gender differences, the following tests were applied: T-test, Cohen d and $\chi 2$ tests. Pearson's correlations were calculated in order to quantify the connection between CRF and the body adiposity parameters. Diagnosis screening tests (Swets, 1973) (sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (LR+), and negative likelihood ratio (LR-)) and ROC (receiver operating characteristic) curve analysis have been applied in the determination of cut-off values for analyzed parameters. In addition, the present sample was classified according to the cut-points suggested in the present study and logistic regression analysis with odds ratio (OR) and 95% confidence intervals (CI) was calculated. Univariate and multivariate analysis adjusted for age were used separately for boys and girls. All the analyses were performed using the statistical programs MedCalc 16.8.4® (Ostend, Belgium) and SPSS 24.0® software (SPSS, v. 24.0 for WINDOWS; SPSS Inc., Chicago, IL, USA), and values of $p < 0.05$ were considered statistically significant.

Results

The research was conducted on a sample of 1863 respondents, of whom 957 (51.4%) boys, and 906 (48.6%) girls, all at the age of 7 to 10 years. The average age of the respondents was 8.98 ± 2.37 years.

Table 1 represents the characteristics of the sample. The inspection of Table 1, which represents the values of the arithmetic means, standard deviation, and the level of statistic significance, shows that there are statistically significant differences between the male and female respondents within the variables: BMI (kg/m^2), Waist circumference (cm), Waist-to-height ratio, 20-m shuttle run test (Laps), and 20-m shuttle run test (VO_2 peak). The inspection of the obtained results shows that the boys have a greater body mass index, waist circumference, waist-to-height ratio and achieve better results in the test of assessing the cardio-respiratory fitness, as compared to the girls.

The distribution of the state of obesity, calculated by the body mass index (BMI), WC >75th percentile for age and sex, waist-to-height ratio ≥ 0.50, BMI and waist circumference and BMI and waist-to-height ratio in children regarding their gender, is presented in Table 1. The analysis of Table 1 and inspection of $\chi 2$ tests show that statistically significant differences between the boys and girls exist in the fat calculated by the waist-to-height ratio ≥ 0.50 and BMI

Table 1. Characteristics of the sample

Indicators	Full Sample		Boys		Girls		p Value for Sex	(Cohen d)
	Mean	SD	Mean	SD	Mean	SD		
Age (years)	8.98	2.37	8.90	1.13	9.07	3.20	0.129	0.03
Height (cm)	134.92	9.21	134.89	9.05	134.95	9.37	0.898	0.01
Weight (kg)	34.55	10.44	34.71	10.95	34.39	9.88	0.507	0.03
BMI (kg/m^2)	18.98	3.76	19.18	3.97	18.76	3.52	0.021	0.11
BMI z-score	0.01	0.99	0.01	0.99	0.01	0.99	1.000	0.00
Waist circumference (cm)	61.43	9.05	62.41	9.57	60.41	8.35	0.000	0.22
Waist-to-height ratio	0.45	0.07	0.46	0.07	0.44	0.06	0.000	0.31
Overweight/Obesity[a]	717	38.5%	362	37.8%	355	39.2%	0.290	(N.A)
Obesity (WC >75th percentile for age and sex)[b]	510	23.0%	258	23.3%	252	22.8%	0.414	(N.A)
Obesity (waist-to-height ratio ≥ 0.50)[c]	411	18.4%	253	22.6%	158	14.2%	0.000	(N.A)
BMI and waist circumference	398	21.4%	203	21.2%	195	21.5%	0.457	(N.A)
BMI and waist-to-height ratio	334	17.9%	200	20.9%	134	14.8%	0.000	(N.A)
Stg	3.56	1.45	3.89	1.60	3.21	1.16	0.000	0.49
VO_2max	48.19	3.45	49.04	3.73	47.29	2.86	0.000	0.53

[a] Obesity defined as Cole et al. (2000); [b] >75th percentile waist circumference definition established by De Ferranti et al. (2004); [c] obesity defined as ≥0.50 according to Schwandt and Haas (2016). BMI: body mass index; WHtR, waist-to-height ratio. No applicable (N.A).

Table 2. Diagnostic properties of VO_2 peak (20-m shuttle run test) according to the equation of Léger et al. to detect body fat by age and sex group.

Age/Sex	AUC (95% CI)	Cut-Points, $mL \cdot kg^{-1} \cdot min^{-1}$	Sensitivity (%) (95% CI)	Specificity (%) (95% CI)	LR (+) (95% CI)	LR (–) (95% CI)	PPV (%) (95% CI)	NPV (%) (95% CI)
Boys								
Obesity by WC >75th percentile for age and sex								
7-8 years old	0.792 (0.754 to 0.825)	≤49.0	85.12 (77.5-90.9)	65.52 (60.7-70.1)	2.47 (2.1-2.9)	0.23 (0.1-0.3)	42.4 (36.1-48.9)	93.7 (90.2-96.2)
9-10 years old	0.826 (0.787 to 0.861)	≤47.0	83.17 (74.4-89.9)	69.16 (63.8-74.2)	2.70 (2.2-3.2)	0.24 (0.2-0.4)	45.9 (38.5-53.4)	92.9 (88.9-95.8)
7-10 years old	0.796 (0.769 to 0.821)	≤48.8	87.84 (82.8-91.8)	60.25 (56.6-63.8)	2.21 (2.0-2.4)	0.20 (0.1-0.3)	40.3 (35.9-44.8)	94.2 (91.7-96.1)
Obesity by WHtR (≥0.50)								
7-8 years old	0.796 (0.759 to 0.829)	≤48.6	79.35 (69.6-87.1)	68.25 (63.7-72.6)	2.5 (2.1-3.0)	0.30 (0.2-0.5)	34.3 (27.9-41.1)	94.1 (90.9-96.4)
9-10 years old	0.786 (0.744 to 0.824)	≤47.0	77.95 (69.7-84.8)	71.04 (65.5-76.1)	2.69 (2.2-3.3)	0.31 (0.2-0.4)	53.5 (46.0-60.9)	88.3 (83.5-92.1)
7-10 years old	0.802 (0.775 to 0.827)	≤47.4	73.06 (66.7-78.8)	74.66 (71.4-77.8)	2.88 (2.5-3.3)	0.36 (0.3-0.5)	46.1 (40.8-51.5)	90.3 (87.7-92.6)
Girls								
Obesity by WC >75th percentile for age and sex								
7-8 years old	0.664 (0.619 to 0.706)	≤47.7	66.96 (57.4-75.6)	60.96 (55.7-66.1)	1.72 (1.4-2.1)	0.54 (0.4-0.7)	35.0 (28.7-41.8)	85.4 (80.5-89.5)
9-10 years old	0.716 (0.671 to 0.758)	≤44.8	60.00 (49.7-69.7)	73.8 (68.7-78.4)	2.29 (1.8-2.9)	0.54 (0.4-0.7)	40.8 (32.8-49.2)	86.0 (81.4-89.8)
7-10 years old	0.666 (0.634 to 0.697)	≤47.4	75.47 (69.1-81.1)	50.73 (46.9-54.5)	1.53 (1.4-1.7)	0.48 (0.4-0.6)	32.1 (28.0-36.4)	87.0 (83.3-90.2)
Obesity by WHtR (≥0.50)								
7-8 years old	0.703 (0.659 to 0.744)	≤47.3	65.67 (53.1-76.8)	68.08 (63.3-72.6)	2.06 (1.6-2.6)	0.50 (0.4-0.7)	25.6 (19.2-32.8)	92.2 (88.6-95.0)
9-10 years old	0.687 (0.641 to 0.730)	≤45.7	65.67 (53.1-76.8)	68.08 (63.3-72.6)	2.06 (1.6-2.6)	0.50 (0.4-0.7)	25.6 (19.2-32.8)	92.2 (88.6-95.0)
7-10 years old	0.736 (0.715 to 0.756)	≤47.1	71.71 (66.7-76.3)	66.14 (63.7-68.5)	2.12 (1.9-2.3)	0.43 (0.4-0.5)	33.4 (30.1-36.9)	90.8 (88.9-92.4)

AUC: area under the curve; 95% CI: 95% confidence interval; LR+: positive likelihood ratio; LR: negative likelihood ratio; PPV: positive predictive value; NPV: negative predictive value; WC, waist circumference; WHtR: waist-to-height ratio.

and waist-to-height ratio. It is not established statistically significant differences between the boys and girls in the rest of the indexes of assessing the obesity. The percentage values suggest that a greater percentage of the boys are classified in the category of fat ones, calculated by waist-to-height ratio ≥ 0.50 and BMI and waist-to-height ratio.

For boys and girls (Table 2, VO_2 peak showed significant predictive capacity for obesity (area under the curve, AUCs > 0.66). In boys, when considering the full sample (7-10 years), the best cut-point for VO_2 peak estimated by the equation of Léger et al. to detect body fat by WC were 48.8 to $mL \cdot kg^{-1} \cdot min^{-1}$ and WHtR were 47.4 to $mL \cdot kg^{-1} \cdot min^{-1}$. For girls, when considering the full sample (7-10 years), the best cut-point to detect body fat by WC were 47.4 to $mL \cdot kg^{-1} \cdot min^{-1}$ and WHtR were 47.1 to $mL \cdot kg^{-1} \cdot min^{-1}$.

Across all age and sex groups, CRF was weak to moderate negative correlated with WC and WHtR (Table 3).

Finally, according to cut-points suggested (Table 2), adolescents with low CRF were more likely to be obese either by WC or WHtR (Table 4).

Discussion

The basic results of the present study suggest that the cardio-respiratory fitness (estimated by 20-m shuttle run test) presented discriminatory ability in identifying a poor health profile (estimated by body fat parameters) in both girls and boys aged 7-10 years. Additionally, the suggested cut-points for low CRF were associated with obesity in all ages and sexes.

The study results are in accordance with the research conducted on a sample of 8740 Canadian children at the age of 8.0-12.9 years, and these results show the negative connection between the 20-m shuttle run test and and cardiometabolic risk (as assessed by adiposity measures), and that CRF cut-points obtained by ROC analysis have a good discriminative power of predicting the obesity (Silva et al., 2018). In the present research, the offered optimum CRF cut-points for children of 8 to 12 years were 41 $mL \cdot kg^{-1} \cdot min^{-1}$ for the boys and 39 $mL \cdot kg^{-1} \cdot min^{-1}$ for the girls. In another similar research which has been conducted on a sample of 16.619 British children at the age of 11-13.9 years from Liverpool (Boddy et al., 2012), the offered values for identification of children exposed to the risk of obesity were 41.9 $mL \cdot kg^{-1} \cdot min^{-1}$ for girls, and 46.96 $mL \cdot kg^{-1} \cdot min^{-1}$ for boys. In research conducted on a sample of 72.505 adolescents from Chille and Columbia, at the age of 13 and 15 years (Prieto-Benavides et al., 2019), the offered values of children exposed to obesity risk were 43.77 $mL \cdot kg^{-1} \cdot min^{-1}$ for boys and 38.53 $mL \cdot kg^{-1} \cdot min^{-1}$ for girls. In our research, regarding the whole sample of the male respondents, the optimal cut-points for WC was 48.8 $mL \cdot kg^{-1} \cdot min^{-1}$ while for WHtR it was 47.4 $mL \cdot kg^{-1} \cdot min^{-1}$. The whole sample of female respondents has the optimal cut-points' value for WC of 47.4 $mL \cdot kg^{-1} \cdot min^{-1}$, while those of WHtR were 47.1 $mL \cdot kg^{-1} \cdot min^{-1}$.

Two studies of research (Lang et al., 2019; Ruiz et al., 2016) regarding CRF cut-points to identify red flags for healthy and unhealthy phenotypes in children and adolescents, offer two temporary international referent criterion standards of 42 $mL \cdot kg^{-1} \cdot min^{-1}$ и 35 $mL \cdot kg^{-1} \cdot min^{-1}$ for boys and girls at the age of 8-18 years, respectively.

Table 3. Pearson correlation coefficient of association between cardiorespiratory fitness and body fat parameters by sex

Indicators	Boys			Girls		
	7-8 years old	9-10 years old	7-10 years old	7-8 years old	9-10 years old	7-10 years old
WC (cm)	-0,376*	-0,486*	-0,462*	-0,320*	-0,438*	-0,301*
WHtR	-0,276*	-0,359*	-0,341*	-0,227*	-0,300*	-0,248*

WC, waist circumference; WHtR, waist-to-height ratio. * $p < 0.001$ (r, Pearson correlation coefficient).

Table 4. Association between unhealthy level of cardiorespiratory fitness and obesity by sex

Indicators	Boys		Girls	
	Crude Analysis (OR (95% CI)	Adjusted Analysis (OR (95% CI) †	Crude Analysis (OR (95% CI)	Adjusted Analysis (OR (95% CI) †
Obesity by WC >75th percentile for age and sex				
Low cardiorespiratory fitness				
Sex-age-specific cut-points	9,76 (6,68-14,26)*	9,77 (6,69-14,28)*	3,39 (2,47-4,67)*	3,40 (2,46-4,69)*
Sex-specific cut-points	8,12 (5,54-11,92)*	8,53 (5,78-12,61)*	4,12 (3,27-5,19)*	4,95 (3,84-6,37)*
Obesity by WHtR (≥0.50)				
Low cardiorespiratory fitness				
Sex-age-specific cut-points	7,21 (5,03-10,32)*	7,21 (5,02-10,35)*	3,25 (2,23-4,74)*	3,26 (2,23-4,76)*
Sex-specific cut-points	8,35 (5,65-12,35)*	7,89 (5,33-11,70)*	4,98 (3,84-6,44)*	5,21 (3,96-6,86)*

OR: odds ratio; 95% CI: 95% confidence interval; WC, waist circumference; WHtR, waist-to-height ratio. † Adjusted analyses for age; * Logistic regression ($p < 0.001$).

The cut-points offered in our study are higher than those offered by Lang et al. (2019) and Ruiz et al. (2016). The reason for these differences might lie in the fact that our study makes use only of indexes of assessing the excessive body weight and obesity in order to define the poor health profile, whereas whereas the Ruiz and Lang cut-points used different cardiometabolic factors of risk. In addition, most of those studies have been conducted on a local sample of respondents who might not have the necessary representativity with regard to the whole population level. Further, both studies showed cut-points for CRF for many high-income countries, and, so far, there are very few studies conducted on a large sample of children and adolescents from the West Balkan, and especially from the Republic of North Macedonia (Pireva et al., 2018).

In general, these studies suggest the existence of significant connection between CRF and the indexes of assessing the obesity which is detectable as early as in the childhood and adolescent period, and which can be used in creating strategies and prevention measures for reducing the cardiometabolic factors of risk. The harmful results that are ascribed to the obesity can be reduced to a certain degree by maintaining the suitable levels of CRF (Mintjens et al., 2018; Lang et al., 2018a). In our research, we have also tested the connection between CRF and indexes of assessing obesity as well as the proposed cut-points of low CRF and obesity. The connection between our cut-points for low CRF and obesity give a clear insight of the connections between the unfavourable CRF and the lower health status, and emphasizes the necessity of the public-health intervention for raising the level of physical fitness of young population.

Such kind of interventions – for example in the school environment – should include promotion of physical activity in order to increase the CRF levels (Pozuelo-Carrascosa et al., 2018), which were alluded to in the most recent guidelines for physical activity (Physical Activity Guidelines Advisory Committee, 2018). Having in mind the results obtained in our research and comparing them with 142 studies (Lang et al., 2018b), which have examined the correlation between 20mSRT and different health indicators in children and adolescents, it can be concluded that 20mSRT is positively connected to the physical, physiologic and psycho-social and cognitive health of young persons, and it can be used as a holistic indicator of health which can help to identify the young persons running the risk of developing poor health.

Our research has several limits which should be taken into consideration when interpreting the results. In the first place, the pattern of a vertical zonation of our study does not allow us to explain the causality. Secondly, if the study had covered some other cardiometabolic factors of risk (e.g., dyslipidemia, blood pressure and insulin resistance), some additional information might have been obtained about the prognosticated assessment values. And finally, VO_2peak was established by the formula of results obtained from 20mSRT, but standard methods of testing by direct measuring of oxygen consumption are required to be applied in order to confirm out cut-points.

The chief advantage of the present study is its potential usefulness of the cut-points, which can be used in the training research by the teachers in the subject of Physical Education as well as the health workers in the countries of the West Balkan, and especially in the Republic of North Macedonia. Since 20mSRT is a simple, practical and cheap method of assessing CRF, it can be used in examining the connection between the physical activity and health of children and adolescents with regard to the population level (Lang et al., 2018). Finally, the significance of the present study is the relatively great sample of respondents, which makes it possible

to have a sensible examination of different indicators of the excessive weight and obesity on the level of a whole population in order to have better profile of Macedonian children.

Conclusions

Though a transversal research was conducted, AUC demonstrated moderate discriminative power, and our results confirm the ability and usefulness of CRF (assessed by 20mSRT) in detecting fat in children. Our findings also suggest that the proposed cut-points for low CRF are associated with obesity, in both genders. Therefore, teachers of Physical Education and health workers can use locally the obtained cut-points values for VO_2 as a cheap and practical method which can help to identify children and adolescents under the threat of poor health.

Conflict of interest

Authors have no conflict of interest to disclose.

References

Gontarev, S. & Kalac, R. (2016). Prediction of physical activity factors in macedonian adolescents. *Journal of Physical Education and Sport.*

Gontarev, S., Kalac, R., Ameti, V., & Redjepi, A. (2016). Factors associated with physical activity among Macedonian adolescents in albanian ethnic community. *Iranian journal of public health, 45*(4), 474.

Gontarev, S., Kalac, R., Velickovska, L. A., & Zivkovic, V. (2018). Physical Fitness Reference Standards in Macedonian Children And Adolescent: The Makfit Study. *Nutricion hospitalaria, 35*(6),1275-128. https://doi.org/10.20960/nh.1881

Sahoo, K., Sahoo, B., Choudhury, A. K., Sofi, N. Y., Kumar, R., & Bhadoria, A. S. (2015). Childhood obesity: causes and consequences. *Journal of family medicine and primary care, 4*(2), 187. https://doi.org/10.4103/2249-4863.154628

Balagopal, P., De Ferranti, S. D., Cook, S., Daniels, S. R., Gidding, S. S., Hayman, L. L., ... & Steinberger, J. (2011). Nontraditional risk factors and biomarkers for cardiovascular disease: mechanistic, research, and clinical considerations for youth: a scientific statement from the American Heart Association. *Circulation, 123*(23), 2749-2769. https://doi.org/10.1161/cir.0b013e31821c7c64

Kaminsky, L. A., Arena, R., Ellingsen, Ø., Harber, M. P., Myers, J., Ozemek, C., & Ross, R. (2019). Cardiorespiratory fitness and cardiovascular disease-The past, present, and future. *Progress in cardiovascular diseases, 62*(2), 86-93. https://doi.org/10.1016/j.pcad.2019.01.002

Mintjens, S., Menting, M. D., Daams, J. G., van Poppel, M. N., Roseboom, T. J., & Gemke, R. J. (2018). Cardiorespiratory fitness in childhood and adolescence affects future cardiovascular risk factors: a systematic review of longitudinal studies. *Sports Medicine, 48*(11), 2577-2605. https://doi.org/10.1007/s40279-018-0974-5

Pillsbury, L., Oria, M., & Pate, R. (Eds.). (2013). *Fitness measures and health outcomes in youth.*

Lee, S. J., & Arslanian, S. A. (2007). Cardiorespiratory fitness and abdominal adiposity in youth. *European journal of clinical nutrition, 61*(4), 561-565. https://doi.org/10.1038/sj.ejcn.1602541

Grøntved, A., Ried-Larsen, M., Møller, N. C., Kristensen, P. L., Froberg, K., Brage, S., & Andersen, L. B. (2015). Muscle strength in youth and cardiovascular risk in young adulthood (the European Youth Heart Study). *British journal of sports medicine, 49*(2), 90-94. https://doi.org/10.1136/bjsports-2012-091907

Silva, D. A. S., Lang, J. J., Barnes, J. D., Tomkinson, G. R., & Tremblay, M. S. (2018). Cardiorespiratory fitness in children: evidence for criterion-referenced cut-points. *PLoS One, 13*(8), e0201048. https://doi.org/10.1371/journal.pone.0201048

Pireva, A., Selimi, M., Gontarev, S., & Georgiev, G. (2018). Association between aerobic fitness and high blood pressure in adolescents in Macedonia evidence for criterion-referenced cut-points. *Journal of Physical Education and Sport 18*(2), 853-861.

Schwandt, P., & Haas, G. M. (2016). Is the ratio waist circumference to height (WHtR) of 0.5 a universal measure for abdominal adiposity in children and adolescents? *International Journal of Obesity, 40*(7), 1141-1142.

de Oliveira, R. G., & Guedes, D. P. (2018). Performance of anthropometric indicators as predictors of metabolic syndrome in Brazilian adolescents. *BMC pediatrics, 18*(1), 1-9. https://doi.org/10.1186/s12887-018-1030-1

de Ferranti, S. D., Gauvreau, K., Ludwig, D. S., Neufeld, E. J., Newburger, J. W., & Rifai, N. (2004). Prevalence of the metabolic syndrome in American adolescents: findings from the Third National Health and Nutrition Examination Survey. *Circulation, 110*(16), 2494-2497. https://doi.org/10.1161/01.cir.0000145117.40114.c7

Ashwell, M., & Gibson, S. (2016). Waist-to-height ratio as an indicator of 'early health risk': simpler and more predictive than using a 'matrix'based on BMI and waist circumference. *BMJ open, 6*(3), e010159. https://doi.org/10.1136/bmjopen-2015-010159

Leger, L. A., Mercier, D., Gadoury, C., & Lambert, J. (1988). The multistage 20 metre shuttle run test for aerobic fitness. *Journal of sports sciences, 6*(2), 93-101. https://doi.org/10.1080/02640418808729800

Ramírez-Vélez, R., Rodrigues-Bezerra, D., Correa-Bautista, J. E., Izquierdo, M., & Lobelo, F. (2015). Reliability of health-related physical fitness tests among Colombian children and adolescents: the FUPRECOL study. *PloS one, 10*(10), e0140875. https://doi.org/10.1371/journal.pone.0140875

Swets, J. A. (1973). The relative operating characteristic in psychology: a technique for isolating effects of response bias finds wide use in the study of perception and cognition. *Science, 182*(4116), 990-1000. https://doi.org/10.1126/science.182.4116.990

Boddy, L. M., Thomas, N. E., Fairclough, S. J., Tolfrey, K., Brophy, S., Rees, A., Knox, G., Baker, J. S., & Stratton, G. (2012). ROC Generated Thresholds for Field-Assessed Aerobic Fitness Related to Body Size and Cardiometabolic Risk in Schoolchildren. *PLoS ONE, 7*(9), e45755. https://doi.org/10.1371/journal.pone.0045755

Prieto-Benavides, D. H., García-Hermoso, A., Izquierdo, M., Alonso-Martínez, A. M., Agostinis-Sobrinho, C.,

Correa-Bautista, J. E., & Ramírez-Vélez, R. (2019). Cardiorespiratory fitness Cut-Points are related to body adiposity parameters in Latin American adolescents. *Medicina, 55*(9), 508. https://doi.org/10.3390/medicina55090508

Lang, J. J., Tremblay, M. S., Ortega, F. B., Ruiz, J. R., & Tomkinson, G. R. (2019). Review of criterion-referenced standards for cardiorespiratory fitness: what percentage of 1 142 026 international children and youth are apparently healthy?. *British Journal of Sports Medicine, 53*(15), 953-958. https://doi.org/10.1136/bjsports-2016-096955

Ruiz, J. R., Cavero-Redondo, I., Ortega, F. B., Welk, G. J., Andersen, L. B., & Martinez-Vizcaino, V. (2016). Cardiorespiratory fitness cut points to avoid cardiovascular disease risk in children and adolescents; what level of fitness should raise a red flag? A systematic review and meta-analysis. *British journal of sports medicine, 50*(23), 1451-1458. https://doi.org/10.1136/bjsports-2015-095903

Lang, J. J., Belanger, K., Poitras, V., Janssen, I., Tomkinson, G. R., & Tremblay, M. S. (2018a). Systematic review of the relationship between 20 m shuttle run performance and health indicators among children and youth. *Journal of Science and Medicine in Sport, 21*(4), 383-397. https://doi.org/10.1016/j.jsams.2017.08.002

Pozuelo-Carrascosa, D. P., García-Hermoso, A., Álvarez-Bueno, C., Sánchez-López, M., & Martinez-Vizcaino, V. (2018). Effectiveness of school-based physical activity programmes on cardiorespiratory fitness in children: a meta-analysis of randomised controlled trials. *British journal of sports medicine, 52*(19), 1234-1240. https://doi.org/10.1136/bjsports-2017-097600

Physical Activity Guidelines Advisory Committee (2018). 2018 physical activity guidelines advisory committee scientific report.

Lang, J. J., Tomkinson, G. R., Janssen, I., Ruiz, J. R., Ortega, F. B., Léger, L., & Tremblay, M. S. (2018b). Making a case for cardiorespiratory fitness surveillance among children and youth. *Exercise and sport sciences reviews, 46*(2), 66-75. https://doi.org/10.1249/jes.0000000000000138

ПОРОГОВІ ТОЧКИ КАРДІОРЕСПІРАТОРНОЇ ПІДГОТОВЛЕНОСТІ, ПОВ'ЯЗАНІ З ПАРАМЕТРАМИ ОЖИРІННЯ ТІЛА У МАКЕДОНСЬКИХ ДІТЕЙ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

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Проблематика та цілі. У Республіці Північна Македонія не вистачає критеріїв та стандартів для тестів логістичного застосування, призначених для оцінки кардіореспіраторної придатності (КРП) у дітей та підлітків. Мета дослідження була двоякою: 1) Визначити здатність КРП, що оцінюється за допомогою тесту «20-метровий човниковий біг», розрізняти «здорові» та «нездорові» фенотипи (за показниками ожиріння, такими як ОТ та СТЗ) у дітей; 2) Визначити взаємозв'язок між ожирінням та відносно максимальним споживанням кисню (VO_2peak), перевіреним на відносно великій вибірці македонських дітей. Дослідження проведено на вибірці з 1863 респондентів, з яких 957 (51,4%) були хлопчики та 906 (48,6%) – дівчата віком від 7 до 10 років. Усі вони були учнями 19 початкових шкіл центральної та східної частин Республіки Північна Македонія.

Матеріали і методи. Окружність талії (ОТ) та співвідношення талії та зросту (СТЗ) використовувалися для визначення маркерів ожиріння тіла. КРП вимірювали за допомогою тесту "20-метровий човниковий біг" (VO_2peak). Криві операційних характеристик приймача та логістична регресія були застосовані для встановлення розрізняючої здатності КРП у прогнозуванні параметрів маркерів ожиріння тіла.

Результати. Як для хлопчиків, так і для дівчат, VO_2peak показав значну прогностичну здатність для визначення ожиріння (площа під кривою [AUC] > 0,66). У хлопчиків, при розгляді повної вибірки (7–10 років), найкраща порогова точка для VO_2 peak для визначення жирової маси тіла за допомогою ОТ була до 48,8 мл·кг$^{-1}$·хв$^{-1}$, а СТЗ – до 47,4 мл·кг$^{-1}$·хв$^{-1}$. У дівчат, при розгляді повної вибірки (7-10 років), найкращою точкою для визначення жирової маси тіла за допомогою ОТ була до 47,4 мл·кг$^{-1}$·хв$^{-1}$, а СТЗ – до 47,1 мл·кг$^{-1}$·хв$^{-1}$.

Висновки. Згідно з цими пороговими точками, підлітки з низькою КРП частіше мали ожиріння за ОТ або СТЗ. Граничні значення (порогові точки) КРП можуть бути використані як кількісні маркери для дітей з більш здоровими характеристиками тіла з Республіки Північна Македонія.

Ключові слова: епідеміологія, ожиріння, маса тіла, діти, підлітки.

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ORIGINAL SCIENTIFIC ARTICLE

DOES THE ATHLETES' LEG MUSCLE POWER INCREASE AFTER THE TABATA AQUATIC PROGRAM?

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Abstract

The study purpose. This study aims to evaluate the effect of the Tabata aquatic training method program in increasing the muscle power of beginner level athletes.

Materials and methods. The researcher used a mixed method in this study. There were twenty swimming athletes (n = 20, age: 14.40 ± 1.18 years, height: 169.20 ± 3.18 cm, weight: 62.20 ± 2.26 kg) who agreed to participate in this study and were divided into two groups. The treatment group (n = 10) received the Tabata aquatic program and the control group (n = 10) swam every day without participating in any physical activity. The Tabata aquatic program was carried out for 9 weeks with a frequency of 3 times a week. After implementing the Tabata aquatic program, 10 athletes were interviewed. This study applied a quantitative research instrument, including squat jumps, and a qualitative research instrument, including individual in-depth interviews lasting for 30 minutes each. Analysis of quantitative data using IBM SPSS version 25.0 and qualitative data using thematic analysis was applied.

Results. Quantitative study results showed that there was a significant increase in the squat jumps test (leg muscle power) in the treatment group and vice versa, there was no increase in the control group. However, in qualitative research results, most participants mentioned that the Tabata aquatic program is a fun training method and has a positive effect.

Conclusions. After carrying out the Tabata aquatic program for 9 weeks, we confirmed that this training method has a great impact on improving athletes' leg muscle power in swimming.

Keywords: Leg muscle power, Tabata aquatic, Swimming athletes, Mixed methods.

Introduction

Muscle power is a product of force and movement speed that plays an important role in athlete performance in all competitive sports, such as basketball, martial arts, soccer and swimming (Loturco et al., 2015)which influences sports performance. However, the traditional determination of the specific workload at which power production is maximized (i.e., optimum power load. Previous studies reported that a great muscle power resulted a long throw in shot put training (Zaras et al., 2013). Similar results were shown in judo, a great muscle power could improve athletes' performance much better in the competition (Campos et al., 2018). In sports like soccer, muscle power plays a key component to generate a hard kick (Burhaein, Ibrahim & Pavlovic, 2020). A study conducted by Alricsson, Björklund, Ekström & Östenberg (2016) reported that athletes' experienced a decline in physical condition in the era before and during COVID-19 (Setiawan, Iwandana, Festiawan & Bapista, 2020). Based on these facts and data, athletes and coaches need to find an appropriate training method to increase muscle power.

Nowadays, Tabata training or known as high intensity interval training (HIIT) (Biddle & Batterham, 2015; Foster et al., 2015; Tabata, 2019; becomes popular in among athletes and coaches in several countries (Evangelista et al., 2017; Murawska-Cialowicz et al., 2020) obesity, type-2 diabetes. Tabata is a method that combines high-intensity exercise and rest (Joo, 201515.3 ± 1.2; the final bout, 18.6 ± 0.9; P< 0.001; Sumpena & Sidik, 2016). Tabata training works in 20 seconds intervals of high intensity exercise and 10 seconds for rest and repeated 8 times for a total of 4 minutes (Ekström, Ostenberg, Björklund & Alricsson, 2017). Previous studies reported that the Tabata training method had an effect on increasing muscle power (Gillen & Gibala, 2014). A recent study has proven that Tabata training method is effective for improving physical fitness in handball athletes (Setiawan et al., 2020) and martial arts (Patah et al., 2021). Another advantage of the Tabata training method that has been reported is the ability to increase V02max endurance (Greenlee et al., 2017) and reduce obesity rates (Burhaein et al., 2020). The effects of the Tabata training method have been reported internationally by researchers in various countries (Kong et al., 2016; Wewege et al., 2018; Torma et al., 2019). However, the analysis focused only on traditional Tabata-based training methods or often performed in closed or open spaces, while this research focuses more on evaluating Tabata aquatic which is a training or physical activity carried out in a water with or without music (Rýzková, Labudova, Grznar & Smida, 2018). The Tabata aquatic training method should be carried out twice a week and each exercise must reach an intensity load of 50-85% HRmax (Rebold, Kobak & Otterstetter, 2013). Previous studies have found that Tabata aquatic is effective in improving cardiorespiratory fitness (Mcdaniel et al., 2020). However, as far as we know this research is the first work that evaluate Tabata aquatic training method to increase the leg muscle power of swimming athletes. In addition, our study presents different method from previous studies, namely a mixed method in an effort to evaluate the effect of Tabata aquatic training method has based on a quantitative and qualitative perspective. This research has implications as a valuable information or reference for coaches, lecturers and athletes regarding the importance of using the Tabata aquatic training method and being a solution for trainers about methods that can be used during the COVID-19 pandemic. Therefore, this study aims to evaluate the effect of Tabata aquatic training method on improving athletes' leg muscle power.

Materials and Methods

Participants

This study used a mixed method, which is a type of research that combines quantitative (experimental) and qualitative (in-depth interviews) method. Based on data from previous studies, it shows that mixed method was effective for uncovering and overcoming a problem.

Participants was taken from 20 beginner level swimming athletes in Karawang Regency (age: 14.40 ± 1.18 years, height: 169.20 ± 3.18 cm, weight: 62.20 ± 2.26 kg). Participants were divided into an treatment group (Tabata aquatic group, n = 10), in which the training program was carried out in the water for 9 weeks and a control group (CG, n = 10), in which the participants performed their daily swimming exercise routine or without followed any physical exercise program for 9 weeks. Before starting this research, all participants were asked to write a statement letter about their willingness to participate in all activities in this study. This study was approved by the Indonesian National Sports Committee Karawang Regency (E-177/9/2021) and in accordance with the World Medical Association Code of Ethics (Helsinki Declaration for humans).

Instruments

Quantitative Instruments

In this mixed method study, the instrument for measuring the level of leg muscle power was squat jumps (SJ) (Alemdaroğlu, 2012). All participants work on SJ in twice trials and the best score was used for statistical analysis (García-Pinillos, Camara-Perez, Soto-Hermoso & Latorre-Roman 2017).

Qualitative Instruments

Meanwhile, the qualitative instrument used in-depth interviews with participants with a duration of 30 minutes per person. Interviews were conducted directly and used Bahasa language.

Study organization

This mixed research was conducted from September until October 2021 in Karawang district (Indonesia). There were several meetings that had been held for quantitative research. The first meeting was conducted on September 15, 2021, with 20 participants involved in initial test activities (SJ) and swimming tests. The second meeting on September 8, 2021, the treatment group carried out the Tabata aquatic training program until the 21st meeting (22 October 2021). The 22nd meeting (24 October 2021), all participants carried out the final test activity, namely SJ. The Tabata aquatic training is held in the morning in the swimming pool located at Singaperbangsa University Karawang (Indonesia). This study strictly implement COVID-19 health protocol, for example, all participants and the research team were checked for body temperature and used hand sanitizer prior training. While, the qualitative research was carried out on 27 and 29 October 2021, the treatment group were interviewed for 30 minutes each and the interviews were conducted using Bahasa. The Tabata aquatic program is presented in Table 1.

Table 1. Tabata aquatic program

Training Unit Components	Exercise Activities	Duration
Warm-up	Prestretch and cardiorespiratory warm-up (e.g. Jogging).	10 min
Focus on practice	Exercise is done at high intensity for 20 seconds for one form of exercise and 10 seconds for rest. Tabata aquatic program: Squat jump, jumping jack, barrier hop, high knee.	4 min
Cool-down	Cardiorespiratory cool down and the poststretch.	10 min

Statistical analysis

Quantitative analysis

Normality and homogeneity testing used Shapiro-Wilk analysis and Levene Test ($p > 0.05$). While the descriptive statistics ($M \pm SD$) and the difference in the pre-test and post-test SJ scores of the Tabata aquatic and control groups were tested using Independent Sample t-test analysis. The level applied in this study was $p < 0.05$, which means it is accepted as significant. The size of effect size was calculated as follows: small d: <0.5, medium d: 0.5-0.79 and large d: >0.85. All data were analyzed using the IBM SPSS tool (version 25.0).

Qualitative analysis

The qualitative analysis in this study was thematic, the results of in-depth interviews were coded and categorized into three themes (Ekström, Ostenberg, Björklund & Alricsson 2017), namely: theme 1: Tabata aquatic training experience, theme 2: benefits of training Tabata aquatic and theme 3: disadvantages of Tabata aquatic training.

Results

The normality test results were normally distributed ($p = 0.110>0.05$), similar with homogeneity test ($p = 0.126>0.05$). In the pre-test and post-test of SJ, the Tabata aquatic group showed a significant increase ($p = 0.002<0.05$), it was indicated by the size of effect ($d = 0.76$) (Table 2). Meanwhile, the control group showed that there was no improvement in SJ ($p = 0.567>0.05$) and effect size ($d = 0.00$).

The results of qualitative research through in-depth interviews with participants obtained the following results:

Theme 1: Tabata Aquatic Training Experience

Most of the participants mentioned that "the application of Tabata aquatic makes us feel satisfied and fun while doing leg muscle power training. In addition, we feel Tabata aquatic is the right method to increase leg muscle power during the current pandemic crisis."

While some of the participants stated that "Tabata aquatic provides a lot of training or movement experience for us and we also feel very enthusiastic in practicing because it is accompanied by music."

And the rest argued that "Tabatata aquatic training accompanied by music, so it cause us to not feel bored while doing the exercises. And we agreed to continue using Tabata aquatic to increase our muscle power, even though this research has been completed."

Theme 2: Benefits of Tabata Aquatic Training

Most of the participants expressed the opinion that "The benefits of applying the Tabata aquatic training method are it is easy to implement and fun."

While some argue that "Tabata aquatic increases the muscle mass of our leg, so our swimming speed becomes better."

Some argue that "The Tabata aquatic training method has a better efficiency rate than other types of training or this training can save more time."

Theme 3: Disadvantages of Tabata Aquatic Training

Most of the participants argued that "If physical fitness is not in good condition, Tabata aquatic will pose a risk of injury to the user."

Then some argue that "When going to do Tabata aquatic training it is better to do optimal warm-up, because high-intensity training is possible to cause injury or leg cramps."

Discussion

The objective of this study was to evaluate the effect of the Tabata aquatic training method on increasing athlete's leg power. The main finding in our quantitative study showed that the Tabata aquatic (EG) training method which had been carried out for 9 weeks has a positive effect on increasing leg muscle power (7-10% muscle performance), thus increasing the speed in swimming athletes. The improvement in high muscle power occured because Tabata performed in water (aquatic) has a heavier load than Tabata performed on land, thus requiring the muscles to work more optimally (D'Acquisto et al., 2015). In addition, the form of exercise or movement used in the Tabata aquatic program is explosive with high intensity (80-90%) and it is the key to success in triggering an increase in the power aspect (Fajrin, Kusnanik & Wijono, 2018). Similarly, research by García-Pinillos et al. (2017) found that HIIT/Tabata training resulted in an increase in muscle performance (6-9%), sprint performance, speed swimming and cycling. Even, Herbert et al. (2017) reported that conducted Tabata for 6 weeks can increase the muscle power of master level athletes. On the other hand, the control group (CG) did not show a significant increase in leg muscle power.

While in qualitative research show that most athletes agreed that the Tabata aquatic method is a very fun and not boring exercise because it is accompanied by energetic music and of course this training has a positive effectiveness for improving the condition of leg muscle power possessed by swimming athletes. The results of this study are in line with

Table 2. Differences values in pre-test and post-SJ in the EG and CG groups

Dependent Variable	EG				CG			
	Pre-Test	Post-Test	p	ES (d)	Pre-Test	Post-Test	p	ES (d)
	Mean(SD)	Mean(SD)			Mean(SD)	Mean(SD)		
SJ	42.0 (9.3)	52.8 (11.4)	0.002	0.76	35.2 (4.1)	34.4 (3.9)	0.567	0.011

SJ: Squat Jumps, SD: Standard Deviation, EG: Eksperimental Group, CG: Control Group, p: Signifikansi; ES (d): Effect Size (Cohen's d)

previous studies (García-Pinillos et al., 2017). For example, an aquatic-based Tabata performed for 10 weeks was effective to improve the physical fitness of students (Rýzková et al., 2018).

In summary, our research has implications for providing alternative methods for swimming and other researcher could use this study as a reference for further research. In addition, according to the training effect size, Tabata aquatic has a moderate effect on increasing the leg muscle power of beginner level swimming athletes. Future studies are interesting to follow up, for example comparing the Tabata aquatic training method with Tabata that conducted on land.

Conclusions

Based on the results and findings in this study, it can be concluded that the Tabata Aquatic training method program has been shown to have an effect on increasing leg muscle power. However, this study still has limitations, namely the limited number of participant and scope is relatively small, only from one sport. Therefore, it is suggested further studies need to be carried out with many athletes from other sports. This research has implications for being a solution for coaches to improve the physical condition of athletes during the COVID-19 pandemic crisis and provide information for lecturers, coaches, students or athletes about the importance of using the Tabata aquatic training method.

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Conflict of interest

All researchers declare that there is no conflict of interest in this research.

References

Loturco, I., Nakamura, F. Y., Tricoli, V., Kobal, R., Abad, C. C. C., Kitamura, K., Ugrinowitsch, C., Gil, S., Pereira, L. A., & González-Badillo, J. J. (2015). Determining the optimum power load in jump squat using the mean propulsive velocity. *PLoS ONE, 10*(10), 1-12. https://doi.org/10.1371/journal.pone.0140102

Zaras, N., Spengos, K., Methenitis, S., Papadopoulos, C., Karampatsos, G., Georgiadis, G., Stasinaki, A., Manta, P., & Terzis, G. (2013). Effects of strength vs. Ballistic-power training on throwing performance. *Journal of Sports Science and Medicine, 12*(1), 130-137. http://www.jssm.org

Campos, B. T., Cabido, C. E. T., Soares, Y. M., Pedrosa, G. F., Mendes, T. T., & de Almeida, R. S. V. (2018). Exercício preparatório de força isométrico aumenta o desempenho de potência muscular de judocas. *Journal of Physical Education (Maringa), 29*(1), 1-8. https://doi.org/10.4025/jphyseduc.v29i1.2910

Burhaein, E., Ibrahim, B. K., & Pavlovic, R. (2020). The relationship of limb muscle power, balance, and coordination with instep shooting ability: A correlation study in under-18 football athletes. *International Journal of Human Movement and Sports Sciences, 8*(5), 265-270. https://doi.org/10.13189/saj.2020.080515

Alricsson, M., Björklund, G., Ekström, A., & Hafsteinsson Östenberg, A. (2016). Introducing Tabata intervals and stability exercises in school children by a school-based study. *European Journal of Public Health, 26*(suppl_1). https://doi.org/10.1093/eurpub/ckw174.222

Setiawan, E., Iwandana, D. T., Festiawan, R., & Bapista, C. (2020). Improving handball athletes' physical fitness components through Tabata training during the outbreak of COVID-19. *Jurnal SPORTIF, 6*(2), 375-389. https://doi.org/10.29407/js_unpgri.v6i2.14347

Biddle, S. J. H., & Batterham, A. M. (2015). High-intensity interval exercise training for public health: A big HIT or shall we HIT it on the head? *International Journal of Behavioral Nutrition and Physical Activity, 12*(1), 1-8. https://doi.org/10.1186/s12966-015-0254-9

Foster, C., Farland, C. V, Guidotti, F., Harbin, M., Roberts, B., Tuuri, A., Doberstein, S. T., & Porcari, J. P. (2015). The Effects of High Intensity Interval Training vs Steady State Training on Aerobic and Anaerobic Capacity. *Journal of Sports Science and Medicine, 14*(August), 747-755.

Tabata, I. (2019). Tabata training: one of the most energetically effective high-intensity intermittent training methods. *Journal of Physiological Sciences, 69*(4), 559-572. https://doi.org/10.1007/s12576-019-00676-7

Evangelista, A. L., Evangelista, R. A. G. d. T., Rica, R. L., Machado, A. F., Miranda, J. M. Q., Teixeira, C. V. L. S., Lopes, C. R., & Bocalini, D. S. (2017). Effects of high-intensity calisthenic training on mood and affective responses. *Journal of Exercise Physiology Online, 20*(6), 15-23. https://www.asep.org/resources/jep-online/

Murawska-Cialowicz, E., Wolanski, P., Zuwala-Jagiello, J., Feito, Y., Petr, M., Kokstejn, J., Stastny, P., & Goliński, D. (2020). Effect of hiit with tabata protocol on serum irisin, physical performance, and body composition in men. *International Journal of Environmental Research and Public Health, 17*(10), 1-15. https://doi.org/10.3390/ijerph17103589

Joo, C. H. (2015). Development of a non-damaging high-intensity intermittent running protocol. *Journal of Exercise Rehabilitation, 11*(2), 112-118. https://doi.org/10.12965/jer.15195

Sumpena, A., & Sidik, D. (2016). The Impact of Tabata Protocol to Increase the Anaerobic and Aerobic Capacity. *Journal of Physics: Conference Series, 755*(1). https://doi.org/10.1088/1742-6596/755/1/011001

Ekström, A., Östenberg, A. H., Björklund, G., & Alricsson, M. (2017). The effects of introducing Tabata interval training and stability exercises to school children as a school-based intervention program. *International Journal of Adolescent Medicine and Health, 31*(4), 1-11. https://doi.org/10.1515/ijamh-2017-0043

Gillen, J. B., & Gibala, M. J. (2014). Is high-intensity interval training a time-efficient exercise strategy to improve health and fitness? *Applied Physiology, Nutrition and Metabolism, 39*(March), 409-412. https://doi.org/10.1139/apnm-2013-0187

Patah, I. A., Jumareng, H., Setiawan, E., Aryani, M., & Gani, R. A. (2021). The importance of physical fitness for pencak silat athletes : Home-based weight training tabata and circuit can it work ? *Journal Sport, 6*(1), 86-97. https://doi.org/10.25299/sportarea.2021.vol6(1).6172

Greenlee, T., A., Greene, D., Ward, N., Reeser, G., Allen, C., Baumgartner, N., Cohen, N., Kramer, A., Hillman, C., & Barbey, A. (2017). Effectiveness Of A 16-Week High-Intensity Cardioresistance Training Program In Adults. *The Journal of Strength and Conditioning Research, 31*(9), 2528-2541. https://doi.org/10.1519/JSC.0000000000001976

Kong, Z., Sun, S., Liu, M., & Shi, Q. (2016). Short-Term High-Intensity Interval Training on Body Composition and Blood Glucose in Overweight and Obese Young Women. *Journal of Diabetes Research,* 4073618, 10-12. https://doi.org/10.1155/2016/4073618

Wewege, M. A., Ahn, D., Yu, J., Liou, K., & Keech, A. (2018). High-Intensity Interval Training for Patients With Cardiovascular Disease – Is It Safe? A Systematic Review. Journal of the American Heart Association, 7(21), 1-19. https://doi.org/10.1161/JAHA.118.009305

Torma, F., Gombos, Z., Jokai, M., Takeda, M., Mimura, T., & Radak, Z. (2019). High intensity interval training and molecular adaptive response of skeletal muscle. *Sports Medicine and Health Science, 1*(1), 24-32. https://doi.org/10.1016/j.smhs.2019.08.003

Rýzková, E. V. A., Labudová, J., Grznár, Ľ., & Šmída, M. (2018). Original Article Effects of aquafitness with high intensity interval training on physical fitness. *Journal of Physical Education and Sport, 18*(1), 373-381. https://doi.org/10.7752/jpes.2018.s151

Rebold, M. J., Kobak, M. S., & Otterstetter, R. (2013). The influence of a Tabata interval training program using an aquatic underwater treadmill on various performance variables. *Journal of Strength and Conditioning Research, 27*(12), 3419-3425. https://doi.org/10.1519/JSC.0b013e3182908a09

Mcdaniel, B. B., Naquin, M. R., Sirikul, B., & Kraemer, R. R. (2020). Five Weeks of Aquatic-Calisthenic High Intensity Interval Training Improves Cardiorespiratory Fitness and Body Composition in Sedentary Young Adults. *Journal of Sports Science and Medicine, 19*(1), 187-194. https://doi.org/10.1249/01.mss.0000563036.95297.1d

Alemdaroğlu, U. (2012). The Relationship Between Muscle Strength, Anaerobic Performance, Agility, Sprint Ability and Vertical Jump Performance in Professional Basketball Players. J*ournal of Human Kinetics, 31*(March), 99-106. https://doi.org/10.2478/v10078-012-0016-6

García-Pinillos, F., Cámara-Pérez, J. C., Hermoso, V. M., & Latorre-Román, P. Á. (2017). A High Intensity Interval Training (HIIT)-Based Running Plan Improves Athletic Performance by Improving Muscle Power. *Journal of Strength and Conditioning Research, 31*(1), 146-153. https://doi.org/10.1519/JSC.0000000000001473

D'Acquisto, L. J., Miller, L. J., D'Acquisto, D. M., Roemer, K., & Fisher, M. G. (2015). Physiological and Psychophysical Aspects of Shallow Water Exercise. *International Journal of Aquatic Research and Education, 9*(3). https://doi.org/10.25035/ijare.09.03.05

Fajrin, F., Kusnanik, N. W., & Wijono. (2018). Effects of High Intensity Interval Training on Increasing Explosive Power, Speed, and Agility. *Journal of Physics: Conference Series,* 947, 012045. https://doi.org/10.1088/1742-6596/947/1/012045

Herbert, P., Hayes, L., Sculthorpe, N., & Grace, F. (2017). HIIT produces increases in muscle power and free testosterone in male masters athletes. *Endoc Rine Connec Tions, 6*(7), 430-436. https://doi.org/10.1530/EC-17-0159

ЧИ ЗБІЛЬШУЄТЬСЯ СИЛА М'ЯЗІВ НІГ СПОРТСМЕНІВ ПІСЛЯ ЗАСТОСУВАННЯ ВОДНОЇ ПРОГРАМИ ТАБАТА?

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 6 с., 2 табл., 28 джерел.

Мета дослідження – оцінити вплив програми водних тренувань Табата на збільшення м'язової сили спортсменів-початківців.

Матеріали і методи. У даному дослідженні використано змішаний метод. Двадцять спортсменів-плавців (n = 20, вік: 14,40 ± 1,18 років, зріст: 169,20 ± 3,18 см, маса тіла:

62,20 ± 2,26 кг) погодилися взяти участь у дослідженні та були розділені на дві групи. Експериментальна група (n=10) займалася за водною програмою Tabata, а контрольна група (n = 10) займалася плаванням щодня без будь-якої іншої фізичної активності. Водна програма Табата застосовувалася протягом 9 тижнів 3 рази на тиждень. Після впровадження водної програми Табата було опитано 10 спортсменів. У дослідженні використовувався кількісний аналіз, який включав присідання з вистрибом, та якісний аналіз, який включав індивідуальні докладні опитування тривалістю 30 хвилин кожне. Кількісні дані було проаналізовано за допомогою IBM SPSS версії 25.0 та якісні дані – за допомогою тематичного аналізу.

Результати. Результати кількісного дослідження показали значне збільшення показників у тесті «Присідання з вистрибом» (сила м'язів ніг) в експериментальній групі і, навпаки, у контрольній групі збільшення не спостерігалось. Однак, за результатами якісного дослідження, більшість учасників відзначили, що водна програма Табата є цікавим методом тренувань і має позитивний вплив.

Висновки. Після застосування водної програми Табата протягом 9 тижнів ми підтвердили, що цей метод тренувань має великий вплив на покращення сили м'язів ніг спортсменів-плавців.

Ключові слова: сила м'язів ніг, водна Табата, спортсмени-плавці, змішані методи.

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ORIGINAL SCIENTIFIC ARTICLE

THE EFFECT OF TRAINING BASED ON PART AND WHOLE COMBINATIONS ON SMASH TECHNIQUES IMPROVEMENT IN VOLLEYBALL SPORTS FOR 11-12 YEAR OLD ATHLETES

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Abstract

Objective. This study aims to examine the effectiveness of the part and whole combination-based smash training model on smash techniques in volleyball athletes aged 11-12 years.

Materials and method. This study used an experimental field testing method, with a pretest-posttest control group design approach. The participants were 52 male volleyball athletes aged 11-12 years and had an average weight and height of ±36.02 kg and ±144.63cm. The instrument used to measure the smash technique was a volleyball skill test.

Results. The results of the descriptive analysis showed differences in the mean and standard deviation of the conventional group and the experimental group. The average value of the conventional group is 75.562 with a standard deviation of 8.7956, while the average value of the experimental group is 87.492 with a standard deviation of 1.9343. Hypothesis testing conducted using Mann-Whitney analysis found that the value of Asymp sig (2-tailed) was 0.000 <0.05, which indicates that the hypothesis is accepted.

Conclusions. Knowing the descriptive results and hypothesis testing, it is concluded that the experimental group experienced a significant improvement and was better than the conventional group. Based on the category of posttest average result assessment, the experimental group was included in the very good category. In other words, the experimental group was very competent. On this basis, this research can be used as a reference in training smash techniques for volleyball athletes at the beginner age.

Keywords: training effect, smash technique, volleyball, part and whole combination, 11-12 years old.

Introduction

Volleyball is a team sport. It takes good mental, physical, tactical and technical aspects to improve performance in volleyball (Côté, Baker & Abernethy, 2003; Gonçalves et al., 2021). All of these aspects require training and hard work supported by a systematic, tiered, sustainable and long-term program.

Most practitioners and sports experts state that it takes long-term training for 10 years in a programmed manner to create outstanding athletes in the international arena, both to improve the team and individual abilities (Chevrier et al., 2016; Sulistiyono et al., 2021). In line with other literature, becoming an Olympic champion and winning various events requires approximately 100.00 hours of practice (Güllich, 2014; Baker & Young, 2014). Strengthened by Bompa and Buzzichelli (2019), improving the quality of training requires adequate infrastructure, knowledge of qualified coaches, supporting knowledge other than coaching knowledge, and good quality of competition so that the athletes involved can explore techniques and have high motivation. The synergy of various sectors thus plays a very important role in advancing sports achievements, especially early childhood development which must be optimized.

Balyi, Way and Higgs (2013) stated that the long-term athlete development theory is a process that is carried out systematically according to the athlete's chronological age. The development of basic techniques and skills needs to be optimized from an early age so that when athletes reach the senior stage, they are no longer talking about technical development, but rather maximizing existing techniques and performance and competing experiences to reach peak performance.

Müller (2009) explained that at the age of 10-12 years, volleyball athletes enter the basic development phase. The purpose of training at this stage is the general development of motivation to play volleyball, where the exercises applied are fun and develop perfect form and mastery of basic techniques. The six basic elements in volleyball include serving, reception, setting, block, defense, and attack (Koch & Tilp, 2009). Athletes who master good basic techniques will carry out the defense and attack effectively and efficiently. In this case, the role of the coach is very influential to create young athletes who have adequate basic techniques.

Coaches are required to be like heroes as they must have flexible roles, such as being able to act as parents, older siblings, facilitators, motivators and always updating knowledge to be later shared with the athletes. Thus, the knowledge and skills of athletes will be more developed in terms of cognitive and technical. Tirtawirya, Tomoliyus and Sudarko (2020) explained that being a champion is not easy where all aspects must be programmed and monitored properly so that the athlete's mental, physical and technical progress can be monitored.

Based on the explanation above, it is clear that the role of the trainer is needed to provide a good program, model, and basic technique. The importance of the coach's role is because the first key to increasing peak performance is the perfect technique formed at an early age that can be taught by the coach. However, there are still problems that need to be studied in depth in the application of technical training.

The basic problem for athletes aged 11-12 years, especially in volleyball is the development of basic smash techniques. In line with the opinion of Harrison et al. (1999), it is stated that teaching or training activities are complicated and complex things. Therefore, when using an approach that is not appropriate to the needs, it will be more difficult to develop skills in volleyball athletes, especially at an early age. It is often found that there is an inaccurate perspective that a good exercise is an exercise that emphasizes the quantity or amount of movement, not the quality of the movement. This kind of assumption makes the target of training less clear, whether it is aimed at physical or technical training.

According to a study by Pranopik (2017), the smash technique is the most difficult basic technique to apply to volleyball athletes. This is in line with previous research that one of the most difficult smash techniques to learn is the straight smash technique from starting, jumping, hitting the ball to landing (Dasar et al., 2021).

The previous study applied the basic smash technique training with the drill method. The study found that the applied technique succeeded in improving basic smash skills aged 16-18 (Marzuq, 2018). However, this drilling method is less effective when given at the age of 11-12 years considering that the drill method focuses more on physical exercise because the movement is done quickly and requires good basic techniques before applying this method.

Another study on testing the effectiveness of developing smash drills found that the drill training method was able to improve smash technique skills (Mustaqim, 2019). However, this study was focused on beginner-level volleyball players in high school so it was not suitable when applied to athletes aged 11-12 years. A scientific approach that aims to achieve effective and efficient training success is therefore very much needed (Apidogo, Burdack & Schöllhorn 2021).

Based on the description that has been explained, it was found that there were problems with the volleyball smash training method at the beginner stage at the age of 11-12 years. For this reason, the researcher provides a solution to deal with these problems by applying the exercise model that has been developed by the author, namely through a part and whole combination-based exercise model. The training model of course adheres to multilateral principles, motor skills, and the development of physical literacy that are adapted to the growth and development of young volleyball athletes. The goal of this research was to see how well a training model based on a combination of parts and wholes worked. Researchers have a hypothesis that this method can improve the mastery of smash techniques for volleyball athletes aged 11-12 years.

Materials and methods

Study participants

This research is an experimental study using field testing with a pretest-posttest control group design (Yulianto, & Yudhistira, 2021). The participants were 52 male volleyball athletes aged 11-12 years old, with a height of ±144.63 and a weight of ±36.02. The first step in this study was to conduct a pretest on 52 athletes using a volleyball skill assessment (Fauzi et al., 2019). After that, the A-B-B-A patter was is used to implement match ordinal pairing (MSOP). After all, stages were carried out, 26 athletes were chosen for the control group where the conventional training model was applied and 26 athletes for the experimental group applied the part and whole-based combination training model.

The development of a model certainly cannot be separated from validation. The validity of Aiken's part and whole exercise model used showed results from 0.78 to 0.80 or included in the good category. This categorization is in line with the expert opinion that a coefficient of more than 0.78 is included in the good category (Dewangga, 2020; Dewangga et al., 2021; Yudhistira et al., 2021). Researchers in this study were assisted by four trainers to carry out the treatment that had been designed for group B. Athletes were given treatment with a frequency of 3x a week for 7 weeks. The duration of one training session is 90-120 minutes with adjusted dosage and intensity.

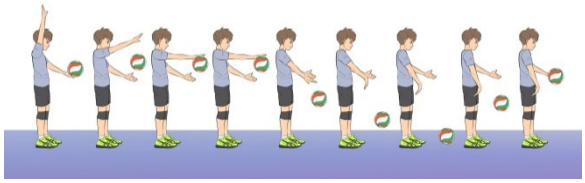
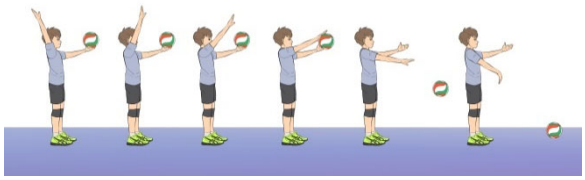
Study organization

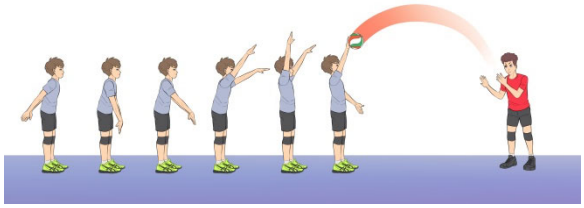
Participants must fill in the attendance list in one practice session. Attendance of participants must reach 80% within 7 weeks of training. The instrument used is a volleyball sports skill assessment from Fauzi et al. (2019). In this case, the aspects that are assessed are an introduction, warm-up, preparatory motion, imposing motion, final motion, and closing with the following assessment categories:

Table 1. Rating Categories

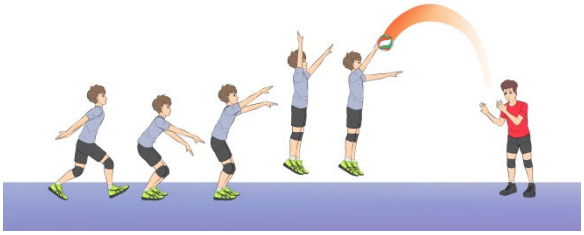
Final Score Criteria	Category	Category Meaning
≥86	Excellent	Very Competent
76 ≥ 85,9	Good	Competent
66 ≥ 75,9	Poor	Incompetent
≤ 65.9	Very Poor	Very Incompetent

Table 2. Part and Whole Based Exercise Programs and Models

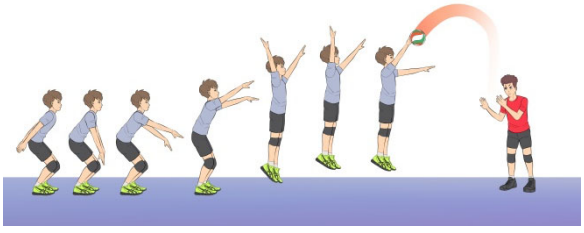
No	Material	Dose
1	Introduction Pray Material Delivery Giving Motivation	5 minutes
2	Warming up Jogging Static flexibility Dynamic flexibility Warming up with the ball	15 minutes
3	 Procedures a. Core Exercises 1: Hitting the volleyball as high as the stomach straight down/floor b. The batting arm is ready straight above the head c. Drop the hands on the ball in a relaxed manner d. Keep your elbows straight when hitting the ball e. Wrist flex f. Hit the ball right in front of the body and right on the palms g. Catch the ball bounce back off the floor h. Repeat the series of movements from the beginning until the touch of the ball on the palm can be felt properly with the appropriate form of technique. i. Note: feel and adjust wrist flick (slow, medium, fast)	10 reps 5 sets
	 Procedures a. Core exercise 2: Hitting a volleyball as high as the head forward b. The batting arm is ready straight above the head c. Drop the hands on the ball in a relaxed manner d. Keep your elbows straight when hitting the ball e. Wrist flex f. Hit the ball right in front of the face and right on the palm g. Aim for the ball 3-4 meters forward h. Do it in pairs. If you practice independently, then do it in front of a wall so that the exercise would be effective and efficient i. Repeat the series of movements from the beginning until the touch of the ball on the palm can be felt properly with the appropriate form of technique j. Note: feel and adjust wrist flick (slow, medium, fast)	10 reps 4 sets



	Procedures	10 reps 3 sets
a.	Core exercise 3: hitting a bouncing ball from someone else	
b.	The ball is tossed by another person (coach or partner with the athlete)	
c.	Both hands are ready straight down the side of the body	
d.	Swing both arms at the same time keeping your elbows straight	
e.	With one swing, the bat is immediately brought up, with the arms straight above the head ready to hit the ball at the highest point of reach	
f.	Keep the other hand relaxed	
g.	Hit the ball with feeling followed by a few steps forward as a follow-up movement of the foot	
h.	Note: The ball stroke must always be at the highest point of the arm reach	



	Procedures	10 reps 3 sets
a.	Core exercise 4: hitting the back ball of someone else with one final smash	
b.	The ball is tossed by someone else	
c.	Both hands are ready straight down the side of the body	
d.	Swing both arms with your elbows still straight at the same time doing one long stride as the final step of the smash	
e.	One swing jump and the bat is immediately brought up, with the arms straight above the head ready to hit the ball at the highest point of reach	
f.	The other hand, body, and legs relaxed	
g.	Hit the ball at the highest point of reach	
h.	Land with both feet at the same time	
i.	Bend the knees slightly during landing to reduce the landing force	
j.	Note: Do it in pairs or with a drill from the trainer so that the exercise would be effective and efficient	



	Procedures	10 reps 3 sets
a.	Core exercise 5: Hitting the back ball from someone else by jumping on the spot	
b.	The ball is tossed by someone else	

c.	Both hands are ready straight down the side of the body with the knees in a bent position	
d.	Swing your arms at the same time straighten your knees with your elbows straight	
e.	With one swing, the bat is immediately brought up, with the arms straight above the head and ready to hit the ball at the highest point of reach	
f.	The other hand relaxed	
g.	Hit the ball with feeling at the highest point of reach	
h.	Land with both feet at the same time	
i.	Bend the knees slightly during landing to reduce the landing force	
j.	Note: Do it in pairs or with a drill from the trainer to be effective and efficient in practice	
4	Cooling Down Jogging Static flexibility	8 minutes
5	Closing Evaluation Motivation Closing pray	5 minutes

Statistical analysis

SPSS 23 was used to analyze the data. The first step in the data processing was to present descriptive data, such as mean and standard deviation. The Mann-Whitney nonparametric test was used for this case's comparative analysis. The purpose of this test was to compare the control group and the experimental group by applying a part and whole-based training model to improve the smash technique of volleyball athletes aged 11-12 years.

Results

Table 3 above presents the results of the control group descriptive analysis where this group has an average pretest value of 73.262 with a standard deviation value of 3.4408, while the posttest average value gets 75.562 with a standard deviation value of 8.7956. In the part and whole group, the mean values of pretest and posttest are 73.485 and 87.492 with standard deviation values of 2.9568 and 1.9343, respectively. It can be concluded that based on the posttest average between the control group and the part and whole group, the part and whole group is better than the control group.

Table 3. Descriptive Analysis Results of Pre-test and Post-test

Group	Variable	Pre-test		Pos-test	
		Mean	SD	Mean	SD
Control Group	Introduction Warming Up Preparatory Move Hit motion Final Move Closing	73.262	3.4408	75.562	8.7956
Part and Whole Group	Introduction Warming Up Preparatory Move Hit motion Final Move Closing	73.485	2.9568	87.492	1.9343

Table 4. Hypothesis testing of the control group and the part and whole group

Group	Mean	Asymp sig (2-tailed)
Post-test-Control Group	75.562	0.000
Post-test- Part and Whole Group	87.492	

The results of hypothesis testing using Mann-Whitney analysis are presented in Table 4. The hypothesis is rejected if the Asymp sig (2-tailed) value> 0.05 and vice versa, while the hypothesis is accepted if the Asyimp sig (2-tailed) value is <0.05. The value of Asymp sig (2-tailed) 0.000 <0.05 is the value obtained in this study which indicates that the hypothesis is accepted. Thus, it can be concluded that there is a significant difference between the control group and the part and whole training model group in improving smash technique in athletes aged 11-12.

Discussion

The part and whole method is a method of learning that aims to teach skills in stages. The learning stage begins with simple and easy movements and progresses to the overall movement (Setiawan & Purnomo, 2020). Another viewpoint stated that the part and whole method is commonly used in educational sports in elementary and junior high schools to teach motor skills ranging from simple to complex (Tuasikal, 2021).

Decaprio (2013) stated that in learning motion, educators must set an example by dividing skills into several parts from simpler ones and leading to broader movements. Reinforced by van Merriënboer & Liesbeth Kester (2008), in learning one must look at the complexity and characteristics of an interrelated skill such as the specification and level of difficulty as well as the duration used to teach the skill.

Previous research revealed that the part and whole training method in achievement sports is a method that provides training from the more general to the specific

(Mariyanto et al, 2020). Sports achievement is an effort to develop and maximize aspects that support the progress of athlete achievement. This is similar to teen volleyball, which necessitates a modern training approach with a few training variations to encourage athletes to develop motor skills. However, expectations and reality are frequently out of sync since some still technical exercises have not applied the principles of practice such as the principle of progressive and the principle of variation. Furthermore, athletes' understanding of a coach's explanation of the basic smash technique is sometimes lacking, making it difficult for them to process the information provided.

Because of the complexity of the smash technique's motion, practicing smash techniques at the age of 11-12 has a high level of difficulty. The cognitive level of children at this age influences their understanding of the material taught by the trainer, necessitating careful method selection. Part training can be a good way to practice smashing techniques. The practice process is modified as it progresses from easy to more difficult stages.

Literature review states that technique in volleyball has a fundamental role related to the actual match. Techniques in volleyball that must be mastered are the technique of starting position, passing, serving, blocking, and attacking. The importance of improving basic techniques to become better is therefore very important so that performance at higher stages can be optimized (Abdiravupovich, 2021). Martens (2012) added that to learn difficult skills, especially complex skills, these skills need to be broken down into smaller and simpler parts or segments. It aims to make it easier for students to apply the material provided.

Based on the opinion explained previously, the part and whole method is an ideal method for learning motion in the context of sports education. This method could, however, be adopted and applied to sports that lead to achievement. This is what drove the researchers to create a part-and-whole-based smash training model and put it to the test in the hopes of improving smash technique mastery in volleyball athletes aged 11 to 12.

Based on the results of the descriptive analysis in the control group, it was found that the mean value of the pretest was 73.262 with a standard deviation of 3.4408. Meanwhile, the average posttest value is 75,562 with a standard deviation of 8.7956. The pretest and posttest values indicated an increase in the posttest scores in the control group.

The results of the descriptive analysis in the part and whole exercise model group showed 73,485 for the mean value of the pretest with a standard deviation of 2.9568. The average value of the posttest of the part and whole exercise model, meanwhile, was 87,492 with 1.9343 as the standard deviation value. This finding indicates that the control group's posttest scores have increased. However, when the posttest scores of the control and part and whole exercise model groups were compared, it was discovered that the control group's posttest score was lower. The hypothesis was tested using Mann-Whitney analysis, which yielded an Asymp sig (2-tailed) value of 0.00 0.05, indicating that the hypothesis was accepted. In other words, the difference between the control group and the part and whole exercise model group was significant.

According to the results of descriptive analysis and hypothesis testing, the part and whole-based smash training model developed by the researcher has been shown to improve the mastery of smash techniques in volleyball athletes aged 11-12 years. Furthermore, in the post-test of the part and whole exercise model group, the outcome assessment category was included in the very good category means that had a very competent meaning. Thus, this finding can be used as a reference in training volleyball athletes at the beginner age and as a reference in writing scientific papers related to sports coaching, particularly volleyball.

Conclusions

Knowing the research findings and discussion, it was found that the experimental group through the application of the part and whole-based smash training model showed a significant improvement and was better than the conventional group. On this basis, this research can be used as a reference to train volleyball athletes' smash techniques at the beginner age.

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Conflict of interest

All authors have declared no conflict of interest.

References.

Côté, J., Baker, J., & Abernethy, B. (2003). *From play to practice: A development framework for the acquisition of expertise in team sports.* In J. L. Starkes & K. A. Ericsson (Eds.), Expert performance in sports: Advances in research on sport expertise (pp. 89-113). Human Kinetics. https://doi.org/10.5040/9781492596257.ch-004

Gonçalves, C. A., Lopes, T. J., Nunes, C., Marinho, D. A., & Neiva, H. P. (2021). Neuromuscular jumping performance and upper-body horizontal power of volleyball players. *The Journal of Strength & Conditioning Research, 35*(8), 2236-2241. https://doi.org/10.1519/jsc.0000000000003139

Chevrier, J., Roy, M., Turcotte, S., Culver, D. M., & Cybulski, S. (2016). Skills trained by coaches of Canadian male volleyball teams: A comparison with long-term athlete development guidelines. *International Journal of Sports Science & Coaching, 11*(3), 410-421. https://doi.org/10.1177/1747954116645013

Sulistiyono, S., Akhiruyanto, A., Primasoni, N., Arjuna, F., Santoso, N., & Yudhistira, D. (2021). The Effect of 10 Weeks Game Experience Learning (Gel) Based Training on Teamwork, Respect Attitude, Skill and Physical Ability in Young Football Players. *Teorìâ ta Metodika Fìzičnogo Vihovannâ, 21*(2), 173-179. https://doi.org/10.17309/tmfv.2021.2.11

Güllich, A. (2014). Selection, de-selection and progression in German football talent promotion. *European journal of sport science, 14*(6), 530-537.

Baker, J., & Young, B. (2014). 20 years later: Deliberate practice and the development of expertise in sport. *International Review of Sport and Exercise Psychology, 7*(1), 135-157. https://doi.org/10.1080/1750984X.2014.896024

Bompa, T. O., & Buzzichelli, C. (2019). *Periodization: theory and methodology of training.* Human kinetics.

Balyi, I., Way, R., & Higgs, C. (2013). *Long-term athlete development.* Human Kinetics.

Müller, A. J. (2009). *Developmental phases for volleyball players.* Creating Active Futures, 375.

Koch, C., & Tilp, M. (2009). Beach volleyball techniques and tactics: A comparison of male and female playing characteristics. *Kinesiology, 41*(1.), 52-59.

Tirtawirya, D., & Tomoliyus, R. A. S. (2020). *Vo_2max Athletes Performance of Yogyakarta Special Region in Pre PON 2019.*

Harrison, J. M., Preece, L. A., Blakemore, C. L., Richards, R. P., Wilkinson, C., & Fellingham, G. W. (1999). Effects of two instructional models-skill teaching and mastery learning – on skill development, knowledge, self-efficacy, and gameplay in volleyball. *Journal of Teaching in Physical Education, 19*(1), 34-57. https://doi.org/10.1123/jtpe.19.1.34

Pranopik, M. R. (2017). Pengembangan Variasi Latihan Smash Bola Voli. *Jurnal Prestasi, 1*(1). https://doi.org/10.24114/jp.v1i1.6495

Dasar, S., Ekawarna, E., Rahayu, F. D., & Yuliawan, E. (2021). Upaya Meningkatkan Hasil Belajar Smash Bola Voli Siswa Kelas X SMK Negeri 5 Tanjab Barat Melalui Pendekatan Gaya Mengajar Latihan Power Tungkai Dengan Menggunakan Modifikasi Bola Gantung. *Jurnal Prestasi,* 5(2), 44-51. https://doi.org/10.24114/jp.v5i2.26501

Marzuq, A. A. (2018). *Meningkatkan keterampilan teknik dasar smash normal bolavoli menggunakan metode drill untuk atlet remaja usia 16-18 yahun di Klub Bolavoli Gajayana Kota Malang* (Doctoral dissertation, Universitas Negeri Malang). https://doi.org/10.17977/um062v3i112021p854-864

Mustaqim, A. (2019). Effectiveness of development of smash ball volley skills exercise model for beginners of age of high school. *IJER-Indonesian journal of educational review, 6*(1), 85-102.

Apidogo, J. B., Burdack, J., & Schöllhorn, W. I. (2021). Repetition without Repetition or Differential Learning of Multiple Techniques in Volleyball? *International Journal of Environmental Research and Public Health, 18*(19), 10499. https://doi.org/10.3390/ijerph181910499

Yulianto, W. D., & Yudhistira, D. (2021). Content Validity of Circuit Training Program and Its Effects on The Aerobic Endurance of Wheelchair Tennis Athletes. *International Journal of Kinesiology and Sports Science, 9*(3), 60-65. https://doi.org/10.7575/aiac.ijkss.v.9n.3p60

Fauzi, Mardapi, & Djemari (2019) *Model Asesmen Keterampilan Olahraga Bola.* Vol. S3 Thesis Program Pascasarjana.

Dewangga Yudhistira, T. (2020). Content Validity of Agility Test in Karate Kumite Category. *Journal of Human Movement and Sports Sciences, 8*(5), 211-216. https://doi.org/10.13189/saj.2020.080508

Dewangga Yudhistira, Siswantoyo, Tomoliyus, Sumaryanti, Devi Tirtawirya, Paryadi, La Ode Adhi Virama, Sinta Naviri, Noralisa (2021). Development of Agility Test Construction: Validity and Reliability of Karate Agility Test Construction in Kata Category. *International Journal of Human Movement and Sports Sciences, 9*(4), 697-703. https://doi.org/10.13189/saj.2021.090413

Yudhistira, D., Suherman, W. S., Wiratama, A., Wijaya, U. K., Paryadi, M. F., Hadi, H., ... & Jufrianis, K. W. P. (2021). *Content Validity of the HIIT Training Program in Special Preparations to Improve the Dominant Biomotor Components of Kumite Athletes.* https://doi.org/10.13189/saj.2021.090527

Setiawan, D., & Purnomo, E. (2020). *The Influence of Part and Whole Learning Methods on the Long Jump Achievement of 11th Grade Students.* https://doi.org/10.5220/0009802707360740

Tuasikal, A. R. S. (2021). Rethinking the Implementation of Part, Whole and Imagery Learning Methods: Comparison Analysis in Basketball Games. Turkish *Journal of Computer and Mathematics Education (TURCOMAT), 12*(11), 992-1004.

Decaprio, R. (2013). *Aplikasi teori pembelajaran motorik di sekolah.* Yogyakarta: Divapress.

Van Merriënboer, J. J., & Kester, L. (2008). Whole-task models in education. *Handbook of research on educational communications and technology,* 3, 441-456.

Mariyanto, M., Soegiyanto, K. S., Kristiyanto, A., & Hidayah, T. (2020, June). Stretching Exercise and Grip Strength on Flat Serve Tennis Skills: Experimental Study on FKOR UNS Students. *In International Conference on Science and Education and Technology* (ISET 2019) (pp. 137-142). Atlantis Press. https://doi.org/10.2991/assehr.k.200620.027

Abdiravupovich, K. A. (2021). Features of the training process of volleyball players of various qualifications. *European Journal of Life Safety and Stability* (2660-9630), 7, 95-98.

Martens, R. (2012). *Successful coaching.* Human kinetics.

ВПЛИВ ТРЕНУВАННЯ НА ОСНОВІ ЧАСТКОВИХ ТА ЦІЛІСНИХ КОМБІНАЦІЙ НА ВДОСКОНАЛЕННЯ ТЕХНІК СИЛЬНОГО АТАКУЮЧОГО УДАРУ У ВОЛЕЙБОЛІ ДЛЯ СПОРТСМЕНІВ 11-12 РОКІВ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

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Мета дослідження – дослідити ефективність моделі тренування сильного атакуючого удару на основі часткових та цілісних комбінацій у вдосконаленні технік удару у волейболі для спортсменів 11-12 років.

Матеріали і методи. У дослідженні використовувався експериментальний метод практичного випробування за планом попереднього та підсумкового тестування контрольної групи. Учасниками були 52 спортсмени-волейболісти чоловічої статі у віці 11-12 років із середньою вагою та зростом ±36,02 кг та ±144,63 см. Інструментом для оцінки техніки удару був тест на волейбольні навички.

Результати. Результати описового аналізу показали відмінності в середньому та стандартному відхиленні у звичайній та експериментальній групах. Середнє значення звичайної групи становить 75,562 із стандартним відхиленням 8,7956, тоді як середнє значення експериментальної групи – 87,492 із стандартним відхиленням 1,9343. Перевірка гіпотези, проведена за допомогою критерію Манна-Уітні, виявила, що значення Asymp sig (двосторонній) було 0,000 <0,05, що вказує на те, що гіпотезу прийнято.

Висновки. Знаючи описові результати та результати перевірки гіпотези, можна зробити висновок, що в експериментальній групі відбулися значні покращення порівняно зі звичайною групою. На основі оцінки середнього результату підсумкового тестування, експериментальну групу віднесено до дуже хорошої категорії. Іншими словами, експериментальна група стала дуже компетентною. Виходячи з цього, дане дослідження може бути використано як орієнтир у тренуванні технік сильного атакуючого удару для волейболістів-початківців.

Ключові слова: тренувальний ефект, техніка сильного атакуючого удару, волейбол, часткова та цілісна комбінація, 11-12 років.

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ORIGINAL SCIENTIFIC ARTICLE

IMPROVEMENT OF QUALITATIVE AND QUANTITATIVE ASPECTS OF THE SPORTS PERFORMANCE OF YOUNG PLAYERS THROUGH HIGH INTENSITY INTERVAL TRAINING

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Abstract

Objective. One of the most widely used training methodologies in football is high intensity interval training (HIIT), which aims to improve performance through training sessions characterised by exercises that involve alternating percentage load intensity. In the literature, although there are studies that demonstrate the effectiveness of HIIT in improving quantitative aspects, i.e. different expressions of strength, there are not as many studies that attest to the same effectiveness in improving qualitative components, i.e. elements related to the precision of specific football gestures.

The study purpose was to verify whether the application of a specific HIIT protocol for football over a given period of time can be equally effective in simultaneously improving the quantitative and precision components.

Materials and methods. The sample analysed consisted of 16 movement players from the ASD Nuova Antoniana sports club, aged between 14 and 15 years. The sample was subjected to a mesocycle of training lasting 8 weeks characterised by the HIIT methodology. Before and after this period, data were collected by means of a battery of tests aimed at assessing rapid, explosive, fast and resistant strength, and passing and shooting skills: the parameters relating to expressions of strength were assessed by means of quantitative tests specific to each parameter; passing and shooting skills were assessed by means of accuracy score tests (from 0 to 4 according to accuracy).

Results. The results showed an improvement in all tested parameters ($p \leq 0.05$). Therefore, the effectiveness of the protocol in improving football performance in terms of quantity and accuracy is confirmed.

Conclusions. This study has increased knowledge of the effects of the HIIT protocol on the performance of young football players.

Keywords: High Intensity Interval Training, football training, football technique, physical skills.

Introduction

Football is one of the most popular sports in the world. It is a team sport played by two teams of 11 players (substitutions are possible due to injuries or tactical reasons). The aim of the game is to score goals against the opposing team by getting the ball all the way across the goal line. Youth teams play according to their category, with varying playing times, field sizes and goals.

It is a situational, open skill sport (Wang et al., 2013), with a high competitive commitment (Altavilla et al., 2018) that assumes an adequate level of individual technique and tactical sense within the team group (Raiola et al., 2020a,b). An important role is also given by the physical characteristics of the athletes, i.e., the ability to express adequate levels of strength both in general and specific terms (D'Isanto et al., 2017) with respect to the role and situations. Finally, the psycho-motivational components should not be forgotten, i.e. determination, courage is the ability to control aggression and tension (Castro-Sánchez et al., 2018).

The type of force that is applied is mixed, as one goes from fast to resistant force in a short time, furthermore, depending on the circumstances one can have concentric and eccentric muscle contraction regimes (Mitchell et al., 2022; Ardern et al., 2015). High levels of maximal strength are not required, but rather a good level of general strength, on which a good expression of fast strength, resistant strength and explosive strength can be built.

Football can be defined as a mixed-energy sport, as the actions of the game last several minutes, or follow each other quickly, giving the body the opportunity to alternate work in both aerobic and anaerobic conditions (Coppola et al., 2019). Especially in modern football, qualitative aspects (Ceruso et al., 2019) should be considered: it is not useful to separate the technical and tactical aspects of the game from the physical abilities of the players, as all these aspects influence, in a decisive way, the quality of the game (Esposito et al., 2019).

For these reasons, the programming of the training process, in order to effectively achieve the set objectives, must include training protocols that, in an integrated manner and with the right load, consider the greatest number of variables, from the subjective ones, related to the structural and psychomotor characteristics of the athletes, to the overall ones of the team as a complex adaptive system, in which the multitude of parts that constitute it, continuously form coordinated (or synergistic) patterns (D'Isanto et al., 2021; Renshaw et al. 2019). One of the most widely used training protocols in football is high-intensity interval training (HIIT) (Aliberti et al., 2021), as it optimally addresses the needs listed above. The first scientific studies demonstrating the effectiveness of HIIT were published in the late 1950s and early 1960s (Roskamm et al., 1962; Astrander et al., 1960). The ability to perform exercises with intermittent intensity levels for prolonged periods is now a key prerogative in competitive football (Federici et al., 2019). Consequently, training strategies and tests have been proposed to monitor and improve players' ability to perform high intensity activities during competition (Raiola & Altavilla, 2020).

The effectiveness of this protocol is attested by several recent studies (Dupont et al., 2004; Ibba et al., 2016) that, however, focus their attention mainly on quantitative aspects (Hostrup et al., 2019; Leahy et al., 2020).

High Intensity Interval Training can be considered as a hybrid of aerobic and anaerobic training. It comprises intense exercises of approximately 30/45 seconds, alternating with 15/30 second rests. This continuous variation of intensity allows both anaerobic and aerobic energy systems to be exploited (Rago et al., 2017; Iaia et al., 2009). The particularity of this methodology is that it can be appropriately adapted to specific performance needs. It can include exercises for the development of strength, under the various expressions and with the intensities most useful for the purpose, or even dexterity, a very important characteristic in the game of football. Dexterity has been defined (Valero-Cuevas et al., 2003) as the ability of a part of the body (e.g. lower limb) to dynamically regulate the intensity and direction of the end-point force when interacting with the environment, such as, for example, in the precision of the pass or the final goal and in the choice of the timing and intensity of force appropriate to the situation.

As can be seen from the literature, it is not clear whether a period of training with the HIIT protocol can bring the same level of improvement in physical abilities and qualitative aspects, i.e. the effectiveness of the gestures with respect to the objectives.

The aim of this work was to verify whether the use of a High Intensity Interval Training protocol specific for football, lasting 8 weeks, was able to improve the sporting performance of young footballers, in terms of both qualitative aspects, relating to the accuracy of the finalisation and passing, and quantitative aspects, i.e. the levels of VO_2max, explosive strength, fast strength, and speed.

Materials and methods

Study participants

Sixteen young male (n=16) soccer players (age: 15.81 ± 0.83 years, height: 162.9 ± 0.6 cm, weight: 58.4 ± 3.8 kg, BMI 22.05 ± 1.22) participated in this study. All players were members of the same youth football team (Società Nuova Antoniana, in the province of Naples), participating in the provincial under-16 championship. All the players had been practicing for about 5 years.

All participants were in good health and participated in all competitions and training sessions.

All players and parents were informed about the research procedures, requirements, benefits and risks and written informed consent was obtained prior to the study.

Study organization

The study lasted a total of 10 weeks: one week of inbound testing, 8 weeks of training with the experimental protocol, one week of outbound testing (Table 1).

The tests, after an adequate warm-up, had a succession and adequate recovery times to allow full psychophysical recovery of the athletes from one test to the next. For each day of testing, first a qualitative test inherent to accuracy was done and then one or two quantitative tests.

On the first day, the ability to finalise and quick strength were assessed. A scoring test was used for the finishing ability: the goal was divided into 6 areas and each area was given a score (4 points for high corners; points for low corners; 2 points for high central area; 1 point for low central area). Each player took 4 shots at three different distances (11 metres, 18 metres and 22 metres). At each distance, 2 shots were taken from a standing position and 2 shots were taken with the ball in motion, with a grazing pass coming from the edge of the penalty area. At the end of the shots, total scores were recorded for each player. Quick strength was assessed with a timed test: a 2.5-metre speed ladder with 6 spaces was placed on the ground, and when the instructor gave the go-ahead the athletes touched each space twice (once with the right and once with the left) in the shortest possible time and were timed.

On the third day, passing ability and explosive strength were assessed. With regard to the passing ability, a scoring test was used: the player led the ball to a line and from that point tried to pass the ball inside a mini-goal measuring 1 metre wide by 50 centimetres high, positioned 11 metres away. Points are awarded according to the accuracy of the pass (3 points for each ball that ends up in the goal, 1 point if the ball hits the post or crossbar, 0 points if the ball ends up outside). Then another ball was placed in the position where the player was at the end of the first pass, with this the player made a high pass from his position to another circular target of radius 2 metres placed 36 metres away, the circle was placed in the centre of a square area of 10 x 10 metres. A further score was then awarded (3 points if the ball lands in the circle or touches its circumference; 1 point if the ball falls inside the larger square; 0 points if the ball ends up outside the square). The total score achieved on 3 attempts was noted. For fast strength (speed), the athletes sprinted 15 metres, the times were recorded and finally the speed values in m/s were calculated using the space-time formula.

Table 1. Experimental protocol

Before the experimental protocol				After the experimental protocol		
Days	**Tests**	**Parameters evaluated**	**Training period**	**Days**	**Tests**	**Parameters evaluated**
1	Warm up 10' (rest 2') Finalization test (rest 5') Speed ladder Test	 Shot accuracy Speed		1	Warm up 20' (rest 2') Finalization test (rest 5') Speed ladder test	 Shot accuracy Speed
2	Rest			2	Rest	
3	Warm up 20' (rest 2') Abalakov JS test (rest 5') Passages ball test	 Explosive Strength Passage accuracy	Eight weeks of HIIT protocol training	3	Warm up 20' (rest 2') Abalakov JS test (rest 5') Passages ball test	 Explosive Strength Passage accuracy
4	Rest			4	Rest	
5	Warm up 15' (rest 2') Cooper test	 Endurance		5	Warm up 15' (rest 2') Cooper test	 Endurance
6	Rest			6	Rest	
7	Rest			7	Rest	

Finally, on the fifth day, endurance strength was assessed using the yo-yo endurance test. Using a conversion table (Bangsbo, 1997), VO_2 max levels were derived.

After the incoming tests the players underwent an 8-week training protocol. The players trained 3 days a week for about 1 hour and 15 minutes per session. On each day, there was a low-intensity warm-up phase lasting 20 minutes, a middle phase with a HIIT protocol lasting about 25 minutes, and a cool-down phase lasting about 20 minutes.

Table 2 shows the structure of a typical training session developed for the study.

In the first mesocycle (4 weeks), after the warm-up phase, the players underwent HIIT training lasting 27 minutes, followed by defatigue.

The training in the first mesocycle (Table 3) was structured as follows: seven training stations were set up on the pitch, four for developing strength and one for shooting.

At each station there are two players, who, when the instructor gives the go-ahead, start to perform their exercise.

The exercise must be completed as many times as possible in 1 minute, which allows the players to work at a maximum intensity of between 75 and 90% of VO_2max.

Table 2. Structure of the training session

Phase	Exercises	Sets	Rest between exercitations	Exercitation duration	Rest between series	Phase duration
Warm up	Neuro-muscular activation Core Ability and core stability Dynamic stretching				60"	20'
Core Phase	Circuit with 5 exercitations (alternating work phases of 60" at 75-90% of VO_2max with active recovery of 30")	3	30"	60"	60"	23'10"
Final phase	Low intensity exercise Stretching					20'

Table 3. Structure of the first 4-week mesocycle

Exercise	Equipment	Description
1	3 cones	The 3 cones are placed along a straight line 10 meters apart. the subject sprints from the first to the second cone, stops and sprints from the second to the third cone, stops and sprints back
2	4 hoops, 1 cone	Four circles have been placed on the ground in a staggered manner and a cone at a distance of 10 meters, the subject performs a monopodalic lunge inside the circle, with a hop inside the next circle and lunge with the opposite foot, at the end of the circles perform a sprint of 10 meters
3	1 trampoline, 1 cone, 1 hoop	The trampoline and hoop were placed close together and the cone 10 meters away. The subject performs a bipodal jump on the trampoline, lands inside the hoop, and sprints to the cone;
4	4 obstacles 50cm high, 1 cone	The four obstacles have been positioned at a distance of 50 cm from each other and the cone at a distance of 10 m. the subject performs a series of 4 bipodal jumps to overcome the obstacles and immediately after performs a sprint towards the cone
5	1 ball	The subject passes the ball to a teammate who performs a support pass or a high pass, after which the subject kicks the ball into the goal, either by stopping the ball or kicking it directly.

Table 4. Structure of the second 4-week mesocycle

Exercise	Equipment	Description
1	1 speed ladder, 1 cone	A speed ladder of 2.5 meters and 6 spaces and a cone at 6 meters distance from the last space has been placed. the subject performs several gaits on the speed ladder and makes a sprint towards the cone
2	2 obstacles, 1 cone	Two obstacles have been placed on the ground parallel to each other at a distance of 50 centimeters and a cone at a distance of 6 meters. the subject positioned between the two obstacles, performs jump with passage over the obstacle on the right, then returns to the center and performs jump over the obstacle on the left, returns to the center and shoots towards the cone
3	2 sticks, 1 cone	The two rods were placed 50 centimeters apart, and a cone 6 meters away. Subjects positioned themselves before the two rods, performed a single-footed jump between the rods, once they had passed both, returned between the two rods, and then sprinted toward the cone.
4	4 football goals in different colours (1.2×0.8 m), 2 cones 1 ball	Two cones are placed 6 metres apart and the goals on a line 10 metres away from the second cone. The subject leads the ball with his feet from one cone to the other, after which he tries to hit the goal of the colour indicated by the coach.
5	8 cones 1 ball 1 football	The players pass the ball to the instructor who makes a support pass, the players then receive the ball and afterwards either pass it to the small door in the centre of the field goal or throw it to one of the two squares in the corners of the field.

The training in the second mesocycle (Table 4) was structured as follows: four stations for the development of quickness and fast strength, one for the improvement of dribbling, passing and quickness, two for the improvement of passing and receiving.

Statistical analysis

Data were represented as mean ± SD. The Shapiro-Wilk normality test revealed that all recruited data were normally distributed. Within-group differences in psychophysiological responses between pre- and post-protocol results were assessed using the paired sample t-test. Statistical analyses were performed using SPSS software. The level of statistical significance was set at $p \leq 0.05$.

Results

Table 5 shows that there were improvements in all the parameters tested after the period of training with the HIIT protocol. These improvements, as shown in Table 6, are significant ($p \leq 0.05$) in all the parameters tested.

Discussion

The aim of the study was to investigate whether an 8-week HIIT protocol training intervention adapted to football could bring about significant improvements in quantitative parameters (aerobic power, explosive strength, speed) and qualitative parameters of accuracy (in passing and finishing) in young male footballers. The results demonstrated

Table 5. Test results

N=16	VO_2max (ml/min/kg)		Abalakov JS Test (cm)		Speed ladder Test (seconds)		Finalization (score)		Passages (score)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean	38,10±3,92	42,31±5,36	39,1±3,38	42,37±3,97	2,78±0,35	2,33±0,39	20,19±3,49	23,25±4,42	9,06±2,98	11,56±2,85

Table 6. T-test results for paired samples

Paired Samples Test									
Indicators		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Abalakov pre –post	-3.26875	.96728	.24182	-3.78418	-2.75332	-13.517	15	.000
Pair 2	VO_2max pre - post	-4.20750	1.57363	.39341	-5.04603	-3.36897	-10.695	15	.000
Pair 3	Speed ladder pre –post	.45438	.05933	.01483	.42276	.48599	30.636	15	.000
Pair 4	Finalization pre –post	-3.06250	1.38894	.34724	-3.80262	-2.32238	-8.820	15	.000
Pair 5	Passages pre –post	-2.50000	.81650	.20412	-2.93508	-2.06492	-12.247	15	.000

the effectiveness of the protocol, with improvements in every parameter tested.

The results of the study with regard to quantitative aspects are consistent with other previous studies. In a study by Sperlich et al. (2011), it was shown that the 5-week HIIT protocol in youth and adult football improves oxygen uptake (VO_2) and thus performance. The study involved a sample of 19 male football players with an average age of 13.5 ± 0.4 years. The VO_2max, after the HIIT protocol applied, increased significantly (7.0%) from pre to post. Another more recent study (Arslan et al., 2020), which compared the results of two training protocols on two samples of football players with an average age of 14.2±0.5, showed significant improvements in VO_2max levels between pre- and post-training. In addition, the same study found significant results in repeated sprinting as well as other parameters. However, these studies reviewed emphasised the quantitative aspects, leaving out the qualitative ones. The integration of both parameters is the fundamental prerequisite for an optimal performance level (Nelson & Groom, 2012; McCullagh et al. 1990).

Our study sought to investigate the effects of HIIT on these characteristics. And, indeed, improvements determined by the protocol were evident. The improvement in shooting and passing accuracy observed in this study is probably also attributable to a better physical condition achieved through the protocol used, which indirectly contributed to improving these aspects. The fitter athlete generally has a higher tolerance to the effects of fatigue, both central and peripheral (Bartolomei et al., 2017; Noakes, 2012) and, therefore, has a higher level of concentration that allows him to complete motor tasks with precision and effectiveness.

One of the main limitations found in the present study is the relatively small sample size of young male footballers. For this reason, our results may not be generalised to players of different sexes, levels or age groups. Another limitation is represented by the choice of only some of the parameters that may affect the performance of the young footballer. Therefore, further studies could broaden the knowledge on the topic by selecting larger samples and choosing additional parameters that adequately address the needs of footballers according to age, level, gender and role.

Conclusions

In conclusion, this study has increased knowledge of the effects of the HIIT protocol on the performance of young football players. The statistical analysis confirmed the initial hypothesis of a significant improvement in the performance capacity of the subjects. Therefore, the results suggest that athletic trainers and coaches can effectively use this methodology to improve the performance levels of young footballers not only in strength-related aspects, but also in the characteristics of accuracy in passing and finishing. The improvement of these aspects is probably linked to the better physical condition that athletes achieve through this training protocol. Further future studies will aim to investigate this issue.

Conflict of interest

All authors have declared no conflict of interest.

References

Wang, C. H., Chang, C. C., Liang, Y. M., Shih, C. M., Chiu, W. S., Tseng, P., Hung, D. L., Tzeng, O. J., Muggleton, N. G., & Juan, C. H. (2013). Open vs. closed skill sports and the modulation of inhibitory control. *PloS one, 8*(2), e55773. https://doi.org/10.1371/journal.pone.0055773

Altavilla, G., Mazzeo, F., D'Elia, F., & Raiola, G. (2018). Physical commitment and specific work for each role in an elite soccer team. *Journal of Physical Education and Sport, 18*(2), 570-574. https://doi.org/10.7752/jpes.2018.02083

Raiola, G., & Altavilla, G. (2020a). Testing motor skills, general and special coordinative, in young soccer. *Journal of Human Sport and Exercise, 15*(2proc), S206-S212. https://doi.org/10.14198/jhse.2020.15.proc2.11

Raiola, G., Esposito, G., & Sgrò, F. (2020b). The formative value of soccer rules. *Journal of Human Sport and Exercise, 15*(3proc), S656-S663. https://doi.org/10.14198/jhse.2020.15.Proc3.18

D'Isanto, T., Altavilla, G., & Raiola, G. (2017). Teaching method in volleyball service: Intensive and extensive tools in cognitive and ecological approach. *Journal of Physical Education and Sport, 17*(4), 393-400.

Castro-Sánchez, M., Zurita-Ortega, F., Ubago-Jiménez, J. L., Ramírez-Granizo, I. A., & Chacón-Cuberos, R. (2018). Motivational Climate in Youth Football Players. *Behavioral sciences (Basel, Switzerland), 8*(9), 83. https://doi.org/10.3390/bs8090083

Mitchell, A., Holding, C., & Greig, M. (2022). Factors influencing optimum countermovement jump performance and movement strategy in Championship professional football players: implications for player profiling. *Research in sports medicine (Print), 30*(1), 30-40. https://doi.org/10.1080/15438627.2020.1860049

Ardern, C. L., Pizzari, T., Wollin, M. R., & Webster, K. E. (2015). Hamstrings strength imbalance in professional football (soccer) players in Australia. *Journal of strength and conditioning research, 29*(4), 997-1002. https://doi.org/10.1519/JSC.0000000000000747

Coppola, C., & Raiola, G. (2019). Interest in VO2/max capacity: Comparing Norwegian and Italian training. *Journal of Physical Education and Sport,* 19, art. no. 268, pp. 1825-1827.

Ceruso, R., Esposito, G., & D'Elia, F. (2019). Analysis and evaluation of the qualitative aspects of the young players. *Journal of Physical Education and Sport,* 19, 266, pp. 1814-1819. https://doi.org/10.7752/jpes.2019.s5266

Esposito, G., Ceruso, R., D'Isanto, T. (2019). Evaluation of some quantitative aspects in the young soccer players training process during puberty. *Journal of Physical Education and Sport,* 19, art. no. 261, pp. 1777-1783. https://doi.org/10.7752/jpes.2019.s5261

D'Isanto, T., Di Domenico, F., D'Elia, F., Aliberti, S., Esposito, G. (2021). The Effectiveness of Constraints-Led Training on Skill Development in Football. *International Journal of Human Movement, 9*(6),1344-1351. https://doi.org/10.13189/saj.2021.090630

Renshaw, I., Davids, K., Newcombe, D., & Roberts, W. (2019). *The constraints-led approach: Principles for sports coaching and practice design.* Routledge.

Aliberti, S., Calandro, A., Esposito, G., Altavilla, G., & Raiola, G. (2021). Tre allenamenti a confronto: interval training, intermittent training e steady state training per il miglioramento di VO_2max e BMI. *Sportske nauke y zdravљe, 22*(2), 197-204.

Roskamm, H., Reindell, H., & Keul, J. (1962). The physiological bases of various training methods. *Der Sportarzt vereinigt mit Sportmedizin,* 13, 109.

Astrand, I., Astrand, P. O., Christensen, E. H., & Hedman, R. (1960). Intermittent muscular work. *Acta physiologica Scandinavica,* 48, 448-453. https://doi.org/10.1111/j.1748-1716.1960.tb01879.x

Federici, A., Zumbo, F., & Raiola, G. (2019). Use of chains as a means of intensifying the load in resistance training. *Journal of Physical Education and Sport,* 19, art. no. 68, pp. 466-472

Dupont, G., Akakpo, K., & Berthoin, S. (2004). The effect of in-season, high-intensity interval training in soccer players. *Journal of strength and conditioning research, 18*(3), 584-589.

Ibba, G. (2016). *Effetti dell'allenamento intermittente breve ad alta intensità e delle ripetute aerobiche sul Test Repeated Sprint Ability in giovani calciatori d'elite*.

Hostrup, M., Gunnarsson, T. P., Fiorenza, M., Mørch, K., Onslev, J., Pedersen, K. M., & Bangsbo, J. (2019). In-season adaptations to intense intermittent training and sprint interval training in sub-elite football players. *Scandinavian journal of medicine & science in sports, 29*(5), 669-677. https://doi.org/10.1111/sms.13395

Leahy, A. A., Mavilidi, M. F., Smith, J. J., Hillman, C. H., Eather, N., Barker, D., & Lubans, D. R. (2020). Review of High-Intensity Interval Training for Cognitive and Mental Health in Youth. *Medicine and science in sports and exercise, 52*(10), 2224-2234. https://doi.org/10.1249/MSS.0000000000002359

Rago, V., Pizzuto, F., Raiola, G. (2017). Relationship between intermittent endurance capacity and match performance according to the playing position in sub-19 professional male football players: Preliminary results. *Journal of Physical Education and Sport, 17(*2), 688-691. https://doi.org/10.7752/jpes.2017.02103

Iaia, F. M., Rampinini, E., & Bangsbo, J. (2009). High-intensity training in football. *International journal of sports physiology and performance, 4*(3), 291-306. https://doi.org/10.1123/ijspp.4.3.291

Valero-Cuevas, F. J., Smaby, N., Venkadesan, M., Peterson, M., & Wright, T. (2003). The strength-dexterity test as a measure of dynamic pinch performance. *Journal of biomechanics, 36*(2), 265-270. https://doi.org/10.1016/s0021-9290(02)00340-8

Bangsbo (1997). *Yo-Yo Test, Kells Edizioni, Ancona*.

Sperlich, B., De Marées, M., Koehler, K., Linville, J., Holmberg, H. C., & Mester, J. (2011). Effects of 5 weeks of high-intensity interval training vs. volume training in 14-year-old soccer players. *Journal of strength and conditioning research, 25*(5), 1271-1278. https://doi.org/10.1519/JSC.0b013e3181d67c38

Arslan, E., Orer, G. E., & Clemente, F. M. (2020). Running-based high-intensity interval training vs. small-sided game training programs: effects on the physical performance, psychophysiological responses and technical skills in young soccer players. *Biology of sport, 37*(2), 165-173. https://doi.org/10.5114/biolsport.2020.94237

Nelson, L. J., & Groom, R. (2012). The analysis of athletic performance: Some practical and philosophical considerations. *Sport, Education and Society, 17*(5), 687-701. https://doi.org/10.1080/13573322.2011.552574

McCullagh, P., Stiehl, J., & Weiss, M. R. (1990). Developmental modeling effects on the quantitative and qualitative aspects of motor performance. *Research quarterly for exercise and sport, 61*(4), 344-350. https://doi.org/10.1080/02701367.1990.10607498

Bartolomei, S., Sadres, E., Church, D. D., Arroyo, E., Iii, J. A. G., Varanoske, A. N., Wang, R., Beyer, K. S., Oliveira, L. P., Stout, J. R., & Hoffman, J. R. (2017). Comparison of the recovery response from high-intensity and high-volume resistance exercise in trained men. *European Journal of Applied Physiology, 117*(7), 1287-1298. https://doi.org/10.1007/s00421-017-3598-9

Noakes, T. D. (2012). Fatigue is a Brain-Derived Emotion that Regulates the Exercise Behavior to Ensure the Protection of Whole Body Homeostasis. *Frontiers in Physiology,* 3. https://doi.org/10.3389/fphys.2012.00082

ПОКРАЩЕННЯ ЯКІСНИХ ТА КІЛЬКІСНИХ АСПЕКТІВ СПОРТИВНОЇ ПІДГОТОВКИ ЮНИХ ГРАВЦІВ ШЛЯХОМ ВИСОКОІНТЕНСИВНОГО ІНТЕРВАЛЬНОГО ТРЕНУВАННЯ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 6 табл., 31 джерело.

Мета дослідження. Однією з найбільш широко використовуваних методологій тренувань у футболі є високоінтенсивні інтервальні тренування (ВІІТ), спрямовані на підвищення показників за допомогою тренувальних занять, що характеризуються вправами, які передбачають змінну інтенсивність навантаження у відсотках. Хоча є дослідження, які демонструють ефективність ВІІТ у покращенні кількісних аспектів, тобто різних проявів сили, існує не так багато досліджень, які свідчать про таку ж саму ефективність у покращенні якісних компонентів, тобто елементів, пов'язаних з точністю конкретних футбольних рухів.

Метою дослідження було перевірити, чи може застосування конкретного протоколу ВІІТ у футболі протягом певного періоду бути однаково ефективним для одночасного покращення компонентів кількості та точності.

Матеріали і методи. Проаналізована вибірка складалася з 16 рухових гравців зі спортивного клубу ASD Nuova Antoniana у віці від 14 до 15 років. Досліджувані приймали участь у мезоциклі тренувань тривалістю 8 тижнів, з використанням методології ВІІТ. До та після цього періоду збиралися дані за допомогою батареї тестів, спрямованих на оцінку швидкісної, вибухової сили, швидкісно-силових якостей, а також навичок передачі та удару: параметри, пов'язані з проявом сили, оцінювалися за допомогою кількісних тестів, призначених для кожного параметру; навички передачі та удару оцінювалися за допомогою тестів на влучність (від 0 до 4 балів за влучністю).

Результати. Результати показали покращення за всіма перевіреними параметрами ($p \leq 0,05$). Таким чином, ефективність протоколу у покращенні футбольних показників кількості та точності підтверджено.

Висновки. Дане дослідження розширило знання про вплив ВІІТ на результативність молодих футболістів.

Ключові слова: високоінтенсивне інтервальне тренування, тренування з футболу, футбольна техніка, рухові навички.

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ORIGINAL SCIENTIFIC ARTICLE

THE ACUTE EFFECTS OF SMALL-SIDED GAMES ON HAMSTRING STRENGTH IN YOUNG SOCCER PLAYERS

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Abstract

The study purpose. The Small-side games (SSG) are high intensity drills very popular in soccer training. The knowledge of the acute effects of the exercises that make up the training session is very relevant especially to reduce youth soccer injury risk. This study aim to assessment the acute effects of SSG on hamstring eccentric strength and to know the lower limb strength asymmetries (LLSA) in young soccer players.

Materials and methods. The sample is composed of male young soccer players Under 17 (n = 24, 16.6 ± 0.5 years, 168.8 ± 4.6 cm, 58.2 ± 3.5 kg). Before and after SSG (4vs4, 3×4 min, 3min recovery, no goalkeepers) the hamstring eccentric strength and the lower limb eccentric strength asymmetry were evaluated used a specific dynamometer (N3 Easytech, Italy) and relative software. Every young soccer player performed a single repetition of the Nordic hamstring exercise with dynamometer; after about 2 minutes, instead, they performed 5 repetitions of the same exercise, without interruption. For both assessments, were detected the eccentric strength and the LLSA.

Results. The hamstring eccentric strength assessment show substantial and statistically significant differences in the assessment in comparison pre-post values. A significant reduction was observed for eccentric strength peak ($p < 0.018$ and $p < 0.014$ for right/left limb), for eccentric average strength ($p < 0.017$ and $p < 0.006$ for right/left limb). The eccentric peak strength asymmetry value and the average strength asymmetry value revealed a significant increase ($p < 0.0001$).

Conclusions. The reduction of strength after SSG requires careful consideration of the exercises order in the training session. The practitioners can plan training sessions and apply SSGs more effectively, with more attention to the effects on hamstrings.

Keywords: hamstring, prevention, young soccer player, small-sided games.

Introduction

Today research tends to always bring new knowledge to the young player training (Esposito et al., 2019; Raiola & Altavilla, 2020; Ceruso et al., 2019). These contributions concern both general defined training (Fischetti et al., 2019; Barbalho et al., 2018; D'Isanto et al., 2019) and the one defined as specific (Köklü et al., 2015; Sanchez-Sanchez et al., 2019; Sannicandro et al., 2019a).

Within the exercises mainly used in sport-specific training there are the so-called Small-Sided Games (SSG) (Halouani et al., 2017; Castillo et al., 2021).

The SSG are high intensity drills very popular in soccer training (Kunz et al., 2019; Selmi et al., 2018; Zurutuza et al., 2020). These exercises are used to achieve technical, tactical and conditioning goals, both with adult soccer players and with young players: today, in fact, the staff are continuously looking for exercises that can increase the soccer player performance effectiveness in all competitive levels (Miranda et al., 2021; Sannicandro et al., 2020, 2021b; Köklü et al., 2020).

The literature on the SSG topic is very wide and today allows us to know in an analytical way the internal and external load of many formats, from 1v1 to 10vs10 (Coutinho et al., 2018; Sanchez-Sanchez et al., 2019), with reference to the field different dimensions (Clemente et al., 2019; Goto & King, 2019) or to its spatial configuration (Coutinho et al., 2018; Sanchez-Sanchez et al., 2019; Sannicandro, 2019).

The relationship between the type of exercise chosen, motor load and soccer injury risk is a very topical research issue (Sannicandro et al., 2021b; Castillo et al., 2019): in fact, despite having a large number of knowledge on injury risk factors, numerous prevention exercises and greater knowledge on muscle, epidemiological studies describe that indirect trauma is on the rise in both men (Diemer et al., 2021; Ribeiro-Alvares et al., 2020; Vicens-Bordas et al., 2020) and female (Larruskain et al., 2018).

The diffusion of sport-specific exercises rather than general ones (which are easier to control in terms of intensity and volume) could lead to an overload on some muscle groups that are most frequently engaged in soccer ability (Madison et al., 2019; Wilmes et al., 2021; Ekstrand et al., 2016).

Infact, today there are few studies that have attempted to know whether SSGs and the most widespread sport-specific exercises in football player training can determine fatigue conditions on specific muscle groups (Greig, 2019; Rhodes et al., 2019; Greig and Siegler, 2009) and on hamstrings in particular (Madison et al., 2019; Wilmes et al., 2021; Small et al., 2010).

Whether for elite soccer players or for the healthy adult population there is research in the literature that allows us to understand how neuromuscular structures respond to high-intensity sport-specific exercises (Diemer et al., 2021; Ribeiro-Alvares et al., 2020; Lovell et al., 2016) or following real or simulated matches (Matthews et al., 2017; Marshall et al., 2014; Madison et al., 2019), for youth soccer the studies carried out are numerically lower (Perroni et al., 2018; Köklü et al., 2020).

Similarly, modest attention has been paid to assessing the hamstring strength for injury prevention in youth soccer (Sannicandro et al., 2019), although it is known, the relationship between values of hamstring eccentric strength and injury risk in sports where high running speeds are required (Lee et al., 2018; Beato et al., 2021; Opar et al., 2021).

The preventive strategies organization can not characterize the top player or the adult athlete, but must be placed above all in the athlete training and athlete evolution process: in this phase the risk factors monitoring offers greater guarantees of long-term success (Opar et al., 2015; White et al., 2018; Leister et al., 2018). The identification at the young age of imbalances and strength asymmetries allow an early intervention that can contrast a potential injury risk scenario. Recent studies show that even in Under 20 soccer players the hamstring injury incidence has its relevance, reaching 18% of total traumas (Ribeiro-Alvares et al., 2020;) or about 35%, according to other epidemiological studies (Valle et al., 2018).; even young players have very high risk factors of injury, such as reduced active flexibility, lower limb asymmetry, functional and core stability deficits (Buckthorpe et al., 2019; Crossley et al., 2020; Lu et al., 2020).

Despite the high incidence of hamstring injuries in soccer players, the most recent literature does not seem exhaustive in addressing the strength asymmetries and muscle imbalances issues in young players following sport-specific exercises. The investigations are mainly limited to over 18 years old soccer players or/and adults (Daneshjoo et al., 2012, 2013; Śliwowski et al. 2015; Lehnert et al., 2018); therefore, an open problem remains the evaluation of eccentric strength and the evaluation of the asymmetry of strength of the lower limb in the young player.

The purpose of this study was to determine the effects of SSG variations on hamstring strength and in strength asymmetry values in elite young soccer players.

Materials and methods

Study participants

The sample is composed of male young soccer players Under 17 (n = 24) belonging to a professional team, whose age, height, weight and Body Mass Index were respectively (mean ± ds) 16,6 ± 0,5 years, 168,8 ± 4,6 cm, 58,2 ± 3,5 kg e 20,7 ± 1,1 kg/m^2. The young soccer players who had an hamstring injury in the previous 12 months were excluded from the assessment.

The evaluation tool was routinely employed by staff, however, the evaluation was carried out after receiving the parent informed consent and with the presence of the team's medical staff. Moreover, all participants were informed about the aim of the study and the relevance of the assessment. Additionally, the research design and procedures complied with the standards set out in the Declaration of Helsinki and was approved by the regional soccer ethics committee.

Study organization

To assess the hamstring eccentric strength and the lower limb eccentric strength asymmetry have been used a specific dynamometer (N3, Easytech, Italy) with specific software. This tool detects the strength expressed during the Nordic Hamstring exercise (Fig.1). The tool and the software allow to measure the peak force and the average force if you perform a number of repetitions higher than one.

The study participants became familiar with the used dynamometer in the two sessions before the evaluation. The evaluation was carried out in the field at a temperature of 23 °C

Before the evaluation all the participants followed a warm-up phase that was the same for everyone and included a low intensity running period (10 minute at 60% HRmax), exercises for dynamic stretching and mobility for the lower limbs, for a total duration of about 15 minutes.

The assessment session organization had two phases: in the first, every young soccer player performed a single repetition of the Nordic hamstring exercise with constraint to the N3 dynamometer; after about 2' minutes, instead, they performed 5 repetitions of the same exercise, without interruption. All values were acquired using N3 software: for both assessments, were detected the eccentric strength and the lower limbs strength asymmetry. The asymmetry calculation was obtained through the formula already used in the literature (Ceroni et al., 2012).

The evaluations were carried out after the warm up (pre test) and after the SSG session (post test). The SSG session consisted of 4 vs 4 (3×4 minutes, 3 minutes recovery) in a 24x36m field with ball possession mode and without limitation of consecutive touches.

20 balls were distributed around the perimeter of the pitch and introduced by 4 assistants to avoid moments of pause. At the end of the post-SSG evaluation, the participants returned the perceived exertion assessed by the CR10 Borg scale (Borg, 1982).

Fig. 1. The N3 Easytech dynamometer and the strength assessment: the young soccer player starts the assessment in the traditional start position of Nordic hamstring and slowly descends

Statistical Analysis

Descriptive statistics (M ± SD) were calculated for all assessed variables; Student's paired t-test was used to verify the existence of statistically significant differences between the average values obtained. The significance was set at $p < 0.05$.

Results

The hamstring eccentric strength assessment show substantial and statistically significant differences in the Nordic exercise test with reference to pre-post exercise values.

In particular, the strength peak of right limb in the comparison between pre and post test showed a reduction of about 27.1N (259.1 ± 62.7N vs 232.1 ± 30.4N, $p < 0.018$); the strength peak of left limb in the comparison between pre and post test showed a reduction of about 35.6N (256.3 ± 62.1N vs 220.7 ± 40.2N, $p < 0.041$). The peak strength asymmetry value revealed an increase of about 10.9% (4.45 ± 3.1 vs 15.4 ± 5.6%, $p < 0.0001$).

The average strength of right limb in the comparison between pre and post test showed a reduction of about 26 N (237.4 ± 41.8N vs 211.3 ± 30.1N, $p < 0.017$). The average strength of left limb in the comparison between pre and post test showed a reduction of about 33 N (236.2 ± 42.6N vs 203.2 ± 34.9N, $p < 0.006$). The average strength asymmetry value revealed an increase of about 16.9% (3.9 ± 2.4 vs 20.1 ± 5.2%, $p < 0.0001$). The results are summarized in table 1.

The average value of Borg scale was equal to 7.8±0.7.

Discussion

This study aimed to describe the acute effects deriving from the SSG practice on the hamstring eccentric strength values and on the strength asymmetry values in elite young soccer players.

In the literature, as available, this is the first study that evaluates the hamstring eccentric strength and investigates the lower limb asymmetries in young soccer players after SSG session.

As is the first study that uses a specific dynamometer for the strength hamstring with this type of sample and this type of exercise with young soccer players of elite team.

The care of player preventive factors can not start when the athlete reaches high levels of performance, but must characterize the entire sports training process both for functional and cultural reasons (Sannicandro et al., 2019; Ros et al., 2013).

The attention towards hamstring muscles in the field of soccer strength and conditioning must be even more assertive when looking at the data on the muscle trauma increase related to hamstring in the last 10-15 years (Edouard et al., 2016; Jones et al., 2019; Smpokos et al., 2018). And this incidence is also relevant in youth sport (Valle et al., 2018).

The peak strength values for right and left limb showed a significant percentage decrease respectively of about 10.5% and 13.9%. This decrease is consistent with the results observed in elite soccer players after SSG session on large field (Madison et al., 2019).

Table 1. Peak strength values, average strength values and asymmetry values referred to the Nordic Hamstring assessment

Hamstring strength parameters	Media ± ds	Δ (media ± ds)	p value
Strength peak (N) pre right limb	259.10 ± 62.7	27.1 ± 40.7	0.018
Strength peak (N) post left limb	232.10 ± 30.4		
Strength peak (N) pre right limb	256.30 ± 62,1	35.6 ± 66.1	0.041
Strength peak (N) post left limb	220.70 ± 40.2		
Peak strength asymmetry value pre (%)	4.45 ± 3.1	10.9 ± 6.1	0.0001
Peak strength asymmetry value post (%)	15.40 ± 5.6		
Average strength 5 rep (N) pre right limb	237.40 ± 41.8	26.1 ± 23.4	0.017
Average strength 5 rep (N) post right limb	211.30 ± 30.1		
Average strength 5 rep (N) pre left limb	236.20 ± 42.6	33.1 ± 41.2	0.006
Average strength 5 rep (N) post left limb	203.20 ± 34.9		
Average strength asymmetry value pre (%)	3.90 ± 2.4	16.1 ± 5.5	0.0001
Average strength asymmetry value post (%)	20.10 ± 5.2		

The average strength values for right and left limb showed a significant percentage decrease respectively of about 11% and 14%. No studies have been found in the literature that have monitored the trend of the hamstring strength values following multiple repetitions with Nordic hamstring exercise.

The available studies concern young subjects over the age of 18 years (Daneshjoo et al., 2012, 2013; Śliwowski et al. 2015) or with young adults assessed using isokinetic dynamometer (Lehnert et al., 2018).

This value, however, is extremely important because the execution of more repetitions allows to better analyze the muscular behavior when the effects of fatigue begin to appear (Greig & Siegler, 2009).

The strength decrease observed following SSG exercises agrees with what emerged after 45 minutes of match (Greig & Siegler, 2009) or following technical exercises (Madison et al., 2019; Greig, 2019; Rhodes et al., 2019).

The asymmetry values revealed that the differences in performance between the hamstrings of the two limbs increase after SSG exercise: this increase is statistically significant both for the value of the eccentric strength peak (+ 10.9%, $p < 0.0001$) and for the average strength produced after more repetitions (+ 16.9%, $p < 0.0001$).

Regarding functional asymmetries of lower limb strength in young football players, the literature is more attentive to the differences between dominant / non-dominant limb (Kalata et al., 2020; Maly et al., 2016; Hewitt et al., 2012) , to asymmetries in functional movements (Fort-Vanmeerhaeghe et al., 2020; Marques et al., 2017) to those concerning imbalances (Atkins et al., 2016; Maloney, 2019) rather than what occurs in the hamstring muscle district (Sannicandro et al., 2019).

This aspect seems to be more frequently investigated with reference to the post traumatic picture (Rush et al., 2020; Sherman et al., 2021).

The different strength production in fatigue conditions, on the other hand, can constitute an interesting investigation field especially in sports where high running speeds and high accelerations and decelerations are required (Loturco et al., 2016; Owen et al., 2016) because it exposes the athlete to distribute the load between the two limbs in a way not homogeneous.

The monitoring of this value, on the other hand, represents a relevant indicator for hamstring injury risk reducing (Śliwowski et al., 2015; Mendiguchia et al., 2012): it allows us to understand the effects of peripheral fatigue deriving from sport-specific exercises and the performance relationships (Wilmes et al., 2021; Castillo et al., 2021).

Conclusions

The study requires further analysis in relation to the influence of fatigue resulting from more repetition of SSG exercises to try to understand if the sport-specific exercises volume can affect the lower limb asymmetry increase.

This study has some limitations: it did not monitor the performance differences between the preferred limb for kicking and the other, just as it did not investigate the effects on the strength decrease following SSG exercises carried out on fields of different sizes.

Subsequent studies will have to investigate this issue: a wider sample must be envisaged and eccentric strength and asymmetry must be monitored throughout the competitive season; it is necessary to understand if there are variations related to the session scheduling, to the exercises order structuring or to the competitive season phases.

Conflict of interest

The authors declare no conflict of interest.

References

Esposito, G., Ceruso, R., & D'Elia, F. (2019). The importance of a technical-coordinative work with psychokinetic elements in the youth sectors of soccer academies. *Journal of Physical Education and Sport,* 19, 1843-1851.

Raiola, G., & Altavilla, G. (2020). Testing motor skills, general and special coordinative, in young soccer. *Journal of Human Sport & Exercise,* 15, Supplementary Issue, 1Proc Winter event Costa Blanca: 206-212.

Ceruso, R., Esposito, G., & D'Elia, F. (2019). Coordination attached to the qualitative aspects of football. *Journal of Physical Education and Sport,* 19, 260, 1773-1776.

Fischetti, F., Cataldi, S., & Greco, G. (2019). A combined plyometric and resistance training program improves fitness performance in 12 to 14-years-old boys. *Sport Sciences for Health, 15*(3), 615-621. https://doi.org//s11332-019-00560-2

Barbalho, M., Gentil, P., Raiol, R., Del Vecchio, F. B., Ramirez-Campillo, R., & Coswig, V. S. (2018). Non-Linear Resistance Training Program Induced Power and Strength but Not Linear Sprint Velocity and Agility Gains in Young Soccer Players. *Sports (Basel, Switzerland), 6*(2), 43. https://doi.org/10.3390/sports6020043

D'Isanto, T., D'Elia, F., Raiola, G., & Altavilla, G. (2019). Assessment of sport performance: Theoretical aspects and practical indications. *Sport Mont,* 17, 79-82.

Köklü, Y., Sert, Ö., Alemdaroğlu, U., & Arslan, Y. (2015). Comparison of the physiological responses and time-motion characteristics of young soccer players in small-sided games: the effect of goalkeeper. *Journal of strength and conditioning research, 29*(4), 964-971. https://doi.org/10.1519/JSC.0b013e3182a744a1

Sanchez-Sanchez, J., Sánchez García, M., Asián-Clemente, J.A., Nakamura, F.Y, & Ramírez-Campillo, R. (2019). Effects of the Directionality and the Order of Presentation Within the Session on the Physical Demands of Small-Sided Games in Youth Soccer. *Asian J Sports Med,* 10, 1-8.

Sannicandro, I, Traficante, P, & Cofano, G. (2019a). Hamstring injury prevention: the strength assessment in young soccer players. *MOJ Sports Med., 3*(2), 28-32. https://doi.org/mojsm.2019.03.00075

Halouani, J., Chtourou, H., Dellal, A., Chaouachi, A., & Chamari, K. (2017). Soccer small-sided games in young players: rule modification to induce higher physiological responses. *Biology of sport, 34*(2), 163-168. https://doi.org/10.5114/biolsport.2017.64590

Castillo, D., Raya-González, J., Sarmento, H., Clemente, F. M., & Yanci, J. (2021). Effects of including endurance and speed sessions within small-sided soccer games

periodization on physical fitness. *Biology of sport, 38*(2), 291-299. https://doi.org/10.5114/biolsport.2021.99325

Kunz, P., Engel, F. A., Holmberg, H. C., & Sperlich, B. (2019). A Meta-Comparison of the Effects of High-Intensity Interval Training to Those of Small-Sided Games and Other Training Protocols on Parameters Related to the Physiology and Performance of Youth Soccer Players. *Sports Medicine - Open, 5*(1), 7. https://doi.org/10.1186/s40798-019-0180-5

Selmi, O., Marzouki, H., Ouergui, I., BenKhalifa, W., & Bouassida, A. (2018). Influence of intense training cycle and psychometric status on technical and physiological aspects performed during the small-sided games in soccer players. *Research in Sports Medicine, 26*(4), 401-412.

Zurutuza, U., Castellano, J., Echeazarra, I., Guridi, I., & Casamichana, D. (2020). Selecting Training-Load Measures to Explain Variability in Football Training Games. *Front. Psychol.,* 10, 2897. https://doi.org/fpsyg.2019.02897

Miranda, G., Aliberti, S., & Invernizzi, P.L. (2021). Effects of an 8-week intermittent aerobic training program on aerobic power in a professional soccer team. *Journal of Human Sport and Exercise, 16*(3proc), S1031-S1038. https://doi.org/10.14198/jhse.2021.16.Proc3.20

Sannicandro, I., Piccinno, A., Rosa, A.R., Raiola, G., Cofano, G. (2020). Analysis of external load during SSG 5vs5 with and without external wildcard (jolly) soccer players. *Sport Science,* 14, 65-71.

Sannicandro, I. (2021b). Small-sided games and size pitch in elite female soccer players: A short narrative review. *Journal of Human Sport and Exercise, 16*(2proc), S361-S369.

Köklü, Y., Cihan, H., Alemdaroğlu, U., Dellal, A., & Wong, D. P. (2020). Acute effects of small-sided games combined with running drills on internal and external loads in young soccer players. *Biology of sport, 37*(4), 375-381. https://doi.org/10.5114/biolsport.2020.96943

Coutinho, D., Gonçalves, B., Santos, S., Travassos, B., Wong, D. P., & Sampaio, J. (2019). Effects of the pitch configuration design on players' physical performance and movement behaviour during soccer small-sided games. *Research in Sports Medicine, 27*(3), 298-313. https://doi.org/10.1080/15438627.2018.1544133

Clemente, F. M., Sarmento, H., Rabbani, A., Van Der Linden, C. M. I. (Niels), Kargarfard, M., & Costa, I. T. (2019). Variations of external load variables between medium- and large-sided soccer games in professional players. Research in Sports Medicine, 27(1), 50-59. https://doi.org/10.1080/15438627.2018.1511560

Goto, H., & King, J.A. (2019). High-intensity demands of 6-a-side small-sided games and 11-a-side matches in youth soccer players, Pediatr Exerc Sci, 31(1):85-90.

Sannicandro, I. (2019). Small-Sided Games configuration pitch and external motor load relationship in young soccer players: narrative literature review, Journal of Physical Education and Sport, 19 (Supplement issue 5), 1989-1993.

Sannicandro, I., Belli, E., & La Torre, A. (2021b). Warm up and postactivaction potentiation: a very topical debate. *J Sports Med Phys Fitness,* 61, 331-332.

Castillo, D., Rodríguez-Fernández, A., Nakamura, F. Y., Sanchez-Sanchez, J., Ramirez-Campillo, R., Yanci, J., Zubillaga, A., & Raya-González, J. (2019). Influence of Different Small-Sided Game Formats on Physical and Physiological Demands and Physical Performance in Young Soccer Players. *Journal of strength and conditioning research.* Advance online publication. https://doi.org/10.1519/JSC.0000000000003114

Diemer, W. M., Winters, M., Tol, J. L., Pas, H., & Moen, M. H. (2021). Incidence of Acute Hamstring Injuries in Soccer: A Systematic Review of 13 Studies Involving More Than 3800 Athletes With 2 Million Sport Exposure Hours. *The Journal of orthopaedic and sports physical therapy, 51*(1), 27-36. https://doi.org/10.2519/jospt.2021.9305

Ribeiro-Alvares, J. B., Dornelles, M. P., Fritsch, C. G., de Lima-E-Silva, F. X., Medeiros, T. M., Severo-Silveira, L., Marques, V. B., & Baroni, B. M. (2020). Prevalence of Hamstring Strain Injury Risk Factors in Professional and Under-20 Male Football (Soccer) Players. *Journal of sport rehabilitation, 29*(3), 339-345. https://doi.org/10.1123/jsr.2018-0084

Vicens-Bordas, J., Esteve, E., Fort-Vanmeerhaeghe, A., Clausen, M. B., Bandholm, T., Opar, D., Shield, A., & Thorborg, K. (2020). Eccentric hamstring strength is associated with age and duratiom of previous season hamstring injury in male soccer players. *International journal of sports physical therapy, 15*(2), 246-253.

Larruskain, J., Lekue, J. A., Diaz, N., Odriozola, A., & Gil, S. M. (2018). A comparison of injuries in elite male and female football players: A five-season prospective study. *Scandinavian journal of medicine & science in sports, 28*(1), 237-245. https://doi.org/10.1111/sms.12860

Madison, G., Patterson, S. D., Read, P., Howe, L., & Waldron, M. (2019). Effects of Small-Sided Game Variation on Changes in Hamstring Strength. *Journal of strength and conditioning research, 33*(3), 839-845. https://doi.org/10.1519/JSC.0000000000002955

Wilmes, E., de Ruiter, C. J., Bastiaansen, B., Goedhart, E. A., Brink, M. S., van der Helm, F., & Savelsbergh, G. (2021). Associations between Hamstring Fatigue and Sprint Kinematics during a Simulated Football (Soccer) Match. *Medicine and science in sports and exercise.* Advance online publication. https://doi.org/10.1249/MSS.0000000000002753

Ekstrand, J., Waldén, M., & Hägglund, M. (2016). Hamstring injuries have increased by 4% annually in men's professional football, since 2001: a 13-year longitudinal analysis of the UEFA Elite Club injury study. *British journal of sports medicine, 50*(12), 731-737. https://doi.org/10.1136/bjsports-2015-095359

Greig, M. (2019). Concurrent changes in eccentric hamstring strength and knee joint kinematics induced by soccer-specific fatigue. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* 37, 21-26. https://doi.org/10.1016/j.ptsp.2019.02.003

Rhodes, D., McNaughton, L., & Greig, M. (2019). The temporal pattern of recovery in eccentric hamstring strength post-soccer specific fatigue. *Res Sports Med., 27*(3), 339-350. https://doi.org/15438627.2018.1523168

Greig, M., & Siegler, J. C. (2009). Soccer-specific fatigue and eccentric hamstrings muscle strength. *Journal of athletic training, 44*(2), 180-184. https://doi.org/10.4085/1062-6050-44.2.180

Small, K., McNaughton, L., Greig, M., & Lovell, R. (2010). The effects of multidirectional soccer-specific fatigue on markers of hamstring injury risk. *Journal of science and medicine in sport, 13*(1), 120-125. https://doi.org/10.1016/j.jsams.2008.08.005

Lovell, R., Siegler, J. C., Knox, M., Brennan, S., & Marshall, P. W. (2016). Acute neuromuscular and performance responses to Nordic hamstring exercises completed before or after football training. *Journal of sports sciences, 34*(24), 2286-2294. https://doi.org/10.1080/02640414.2016.1191661

Matthews, M. J., Heron, K., Todd, S., Tomlinson, A., Jones, P., Delextrat, A., & Cohen, D. D. (2017). Strength and endurance training reduces the loss of eccentric hamstring torque observed after soccer specific fatigue. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* 25, 39-46. https://doi.org/10.1016/j.ptsp.2017.01.006

Marshall, P. W., Lovell, R., Jeppesen, G. K., Andersen, K., & Siegler, J. C. (2014). Hamstring muscle fatigue and central motor output during a simulated soccer match. *PloS one, 9*(7), e102753. https://doi.org/10.1371/journal.pone.0102753

Perroni, F., Pintus, A., Frandino, M., Guidetti, L., & Baldari, C. (2018). Relationship Among Repeated Sprint Ability, Chronological Age, and Puberty in Young Soccer Players, *Journal of Strength and Conditioning Research, 32*(2), 364-371.

Lee, J., Mok, K. M., Chan, H., Yung, P., & Chan, K. M. (2018). Eccentric hamstring strength deficit and poor hamstring-to-quadriceps ratio are risk factors for hamstring strain injury in football: A prospective study of 146 professional players. *Journal of science and medicine in sport, 21*(8), 789-793. https://doi.org/10.1016/j.jsams.2017.11.017

Beato, M., Young, D., Stiff, A., & Coratella, G. (2021). Lower-Limb Muscle Strength, Anterior-Posterior and Inter-Limb Asymmetry in Professional, Elite Academy and Amateur Soccer Players. *Journal of human kinetics,* 77, 135-146. https://doi.org/10.2478/hukin-2020-0058

Opar, D. A., Timmins, R. G., Behan, F. P., Hickey, J. T., van Dyk, N., Price, K., & Maniar, N. (2021). Is Pre-season Eccentric Strength Testing During the Nordic Hamstring Exercise Associated with Future Hamstring Strain Injury? A Systematic Review and Meta-analysis. *Sports medicine (Auckland, N.Z.)*. Advance online publication. https://doi.org/10.1007/s40279-021-01474-1

Opar, D. A., Williams, M. D., Timmins, R. G., Hickey, J., Duhig, S. J., & Shield, A. J. (2015). Eccentric hamstring strength and hamstring injury risk in Australian footballers. *Medicine and science in sports and exercise, 47*(4), 857-865. https://doi.org/10.1249/MSS.0000000000000465

White, A. K., Klemetson, C. J., Farmer, B., Katsavelis, D., Bagwell, J. J., & Grindstaff, T. L. (2018). Comparison of clinical fatigue protocols to decrease single-leg forward hop performance in healty individuals. *International journal of sports physical therapy, 13*(2), 143-151.

Leister, I., Mattiassich, G., Kindermann, H., Ortmaier, R., Barthofer, J., Vasvary, I., Katzensteiner, K., Stelzhammer, C., & Kulnik, S. T. (2018). Reference values for fatigued versus non-fatigued limb symmetry index measured by a newly designed single-leg hop test battery in healthy subjects: a pilot study. *Sport sciences for health, 14*(1), 105-113. https://doi.org/10.1007/s11332-017-0410-5

Valle, X., Malliaropoulos, N., Párraga Botero, J. D., Bikos, G., Pruna, R., Mónaco, M., & Maffulli, N. (2018). Hamstring and other thigh injuries in children and young athletes. *Scandinavian journal of medicine & science in sports, 28*(12), 2630-2637. https://doi.org/10.1111/sms.13282

Buckthorpe, M., Wright, S., Bruce-Low, S., Nanni, G., Sturdy, T., Gross, A. S., Bowen, L., Styles, B., Della Villa, S., Davison, M., & Gimpel, M. (2019). Recommendations for hamstring injury prevention in elite football: translating research into practice. *British journal of sports medicine, 53*(7), 449-456. https://doi.org/10.1136/bjsports-2018-099616

Crossley, K. M., Patterson, B. E., Culvenor, A. G., Bruder, A. M., Mosler, A. B., & Mentiplay, B. F. (2020). Making football safer for women: a systematic review and meta-analysis of injury prevention programmes in 11 773 female football (soccer) players. *British journal of sports medicine, 54*(18), 1089-1098. https://doi.org/10.1136/bjsports-2019-101587

Lu, D., McCall, A., Jones, M., Kovalchik, S., Steinweg, J., Gelis, L., & Duffield, R. (2020). Injury epidemiology in Australian male professional soccer. *Journal of science and medicine in sport, 23*(6), 574-579. https://doi.org/10.1016/j.jsams.2020.01.006

Daneshjoo, A., Mokhtar, A. H., Rahnama, N., & Yusof, A. (2012). The effects of injury preventive warm-up programs on knee strength ratio in young male professional soccer players. *PloS one, 7*(12), e50979. https://doi.org/10.1371/journal.pone.0050979

Daneshjoo, A., Rahnama, N., Mokhtar, A. H., & Yusof, A. (2013). Bilateral and unilateral asymmetries of isokinetic strength and flexibility in male young professional soccer players. *Journal of human kinetics,* 36, 45-53. https://doi.org/10.2478/hukin-2013-0005

Śliwowski, R., Jadczak, Ł., Hejna, R., & Wieczorek, A. (2015). The Effects of Individualized Resistance Strength Programs on Knee Muscular Imbalances in Junior Elite Soccer Players. *PloS one, 10*(12), e0144021. https://doi.org/10.1371/journal.pone.0144021

Lehnert, M., Croix, M. S., Xaverova, Z., Botek, M., Varekova, R., Zaatar, A., Lastovicka, O., & Stastny, P. (2018). Changes in Injury Risk Mechanisms after Soccer-Specific Fatigue in Male Youth Soccer Players. *Journal of human kinetics,* 62, 33-42. https://doi.org/10.1515/hukin-2017-0157

Ceroni, D., Martin, X. E., Delhumeau, C., & Farpour-Lambert, N. J. (2012). Bilateral and gender differences during single-legged vertical jump performance in healthy teenagers. *Journal of strength and conditioning research, 26*(2), 452-457. https://doi.org/10.1519/JSC.0b013e31822600c9

Ros, A. G., Holm, S. E., Fridén, C., & Heijne, A. I. (2013). Responsiveness of the one-leg hop test and the square hop test to fatiguing intermittent aerobic work and subsequent recovery. *Journal of strength and conditioning research, 27*(4), 988-994.

Edouard, P., Branco, P., & Alonso, J. M. (2016). Muscle injury is the principal injury type and hamstring muscle injury is the first injury diagnosis during top-level international athletics championships between 2007 and 2015. *British journal of sports medicine, 50*(10), 619-630. https://doi.org/10.1136/bjsports-2015-095559

Jones, A., Jones, G., Greig, N., Bower, P., Brown, J., Hind, K., & Francis, P. (2019). Epidemiology of injury in English Professional Football players: A cohort study. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* 35, 18-22. https://doi.org/10.1016/j.ptsp.2018.10.011

Smpokos, E., Mourikis, C., Theos, C., & Linardakis, M. (2019). Injury prevalence and risk factors in a Greek team's professional football (soccer) players: a three consecutive seasons survey. *Research in sports medicine (Print), 27*(4), 439-451. https://doi.org/10.1080/15438627.2018.1553779

Kalata, M., Maly, T., Hank, M., Michalek, J., Bujnovsky, D., Kunzmann, E., & Zahalka, F. (2020). Unilateral and Bilateral Strength Asymmetry among Young Elite Athletes of Various Sports. *Medicina (Kaunas, Lithuania), 56*(12), 683. https://doi.org/10.3390/medicina56120683

Maly, T., Zahalka, F., & Mala, L. (2016). Unilateral and ipsilateral strength asymmetries in elite youth soccer players with respect to muscle group and limb dominance. *Int. J. Morphol.,* 34, 1339-1344. https://doi.org/S0717-95022016000400027

Hewitt, J., Cronin, J., & Hume, P. (2012). Multidirectional leg asymmetry assessment in sport. *Strength & Cond Journal,* 34, 82-86.

Fort-Vanmeerhaeghe, A., Bishop, C., Buscà, B., Aguilera-Castells, J., Vicens-Bordas, J., & Gonzalo-Skok, O. (2020). Inter-limb asymmetries are associated with decrements in physical performance in youth elite team sports athletes. *PloS one, 15*(3), e0229440. https://doi.org/10.1371/journal.pone.0229440

Marques, V. B., Medeiros, T. M., de Souza Stigger, F., Nakamura, F. Y., & Baroni, B. M. (2017). The Functional Movement Screen (FMS™) in elite young soccer players between 14 and 20 years: composite score, individual-test scores and asymmetries. *International journal of sports physical therapy, 12*(6), 977-985.

Atkins, S. J., Bentley, I., Hurst, H. T., Sinclair, J. K., & Hesketh, C. (2016). The Presence of Bilateral Imbalance of the Lower Limbs in Elite Youth Soccer Players of Different Ages. *Journal of strength and conditioning research, 30*(4), 1007-1013. https://doi.org/10.1519/JSC.0b013e3182987044

Maloney, S. J. (2019). The Relationship Between Asymmetry and Athletic Performance: A Critical Review. *Journal of strength and conditioning research, 33*(9), 2579-2593. https://doi.org/10.1519/JSC.0000000000002608

Rush, J. L., Norte, G. E., & Lepley, A. S. (2020). Limb differences in hamstring muscle function and morphology after anterior cruciate ligament reconstruction. *Physical therapy in sport : official journal of the Association of Chartered Physiotherapists in Sports Medicine,* 45, 168-175. https://doi.org/10.1016/j.ptsp.2020.06.012

Sherman, D. A., Rush, J. L., Glaviano, N. R., & Norte, G. E. (2021). Hamstrings Muscle Morphology After Anterior Cruciate Ligament Reconstruction: A Systematic Review and Meta-Analysis. *Sports medicine (Auckland, N.Z.).* https://doi.org/10.1007/s40279-021-01431-y

Loturco, I., Nakamura, F. Y., Kobal, R., Gil, S., Pivetti, B., Pereira, L. A., & Roschel, H. (2016). Traditional Periodization versus Optimum Training Load Applied to Soccer Players: Effects on Neuromuscular Abilities. *International journal of sports medicine, 37*(13), 1051-1059. https://doi.org/10.1055/s-0042-107249

Owen A.L., Dunlop G., Rouissi M., Haddad M., Mendes B., & Chamari K. (2016). Analysis of positional training loads (ratings of perceived exertion) during various-sided games in European professional soccer players. *International Journal of Sports Science & Coaching, 11*(3), 374-381.

Mendiguchia, J., Alentorn-Geli, E., & Brughelli, M. (2012). Hamstring strain injuries: are we heading in the right direction? *British journal of sports medicine, 46*(2), 81-85. https://doi.org/10.1136/bjsm.2010.081695

ГОСТРИЙ ВПЛИВ МАЛОСТОРОННІХ ІГОР НА СИЛУ ПІДКОЛІННОГО СУХОЖИЛЛЯ У МОЛОДИХ ФУТБОЛІСТІВ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 8 с., 1 табл., рис. 1, 70 джерел.

Мета дослідження. Малосторонні ігри (SSG) – це інтенсивні тренування, які дуже популярні у тренуванні з футболу. Знання гострих наслідків вправ, які складають тренування, є дуже важливими, особливо для зниження ризику травм у молодіжному футболі. Це дослідження спрямоване на оцінку гострого впливу SSG на ексцентричну силу підколінного сухожилля та на визначення асиметрії сили нижніх кінцівок (LLSA) у молодих футболістів.

Матеріали і методи. Вибірку склали молоді футболісти-чоловіки до 17 років (n = 24, 16,6 ± 0,5 років, 168,8 ± 4,6 см, 58,2 ± 3,5 кг). До і після SSG (4 на 4, 3×4 хв, відновлення 3 хв, без воротарів) ексцентричну силу підколінного сухожилля та асиметрію ексцентричної сили нижньої кінцівки оцінювали за допомогою спеціального динамометра (N3 Easytech, Італія) та відповідного програмного забезпечення. Кожен юний футболіст виконував одноразове повторення скандинавської вправи на підколінне сухожилля з динамометром; приблизно через 2 хвилини вони виконали 5 повторень однієї і тієї ж вправи без перерви. Для обох оцінок були виявлені ексцентрична міцність і LLSA.

Результати. Оцінка ексцентричної сили підколінного сухожилля показує суттєві та статистично значущі відмінності в оцінці в порівнянні з допостовими значеннями. Значне зниження спостерігалося для піку ексцентричної сили ($p < 0,018$ і $p < 0,014$ для правої/лівої кінцівки), для ексцентричної середньої сили ($p < 0,017$ і $p < 0,006$ для правої/лівої кінцівки). Значення ексцентричної пікової асиметрії сили та середнього значення асиметрії сили виявили значне збільшення ($p < 0,0001$).

Висновки. Зниження сили після SSG вимагає ретельного врахування порядку виконання вправ на тренуванні. Практикуючі тренери можуть планувати тренування та ефективніше застосовувати SSG з врахуванням впливу на підколінні сухожилля.

Ключові слова: підколінне сухожилля, профілактика, юний футболіст, малосторонні ігри.

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ORIGINAL SCIENTIFIC ARTICLE

IMPROVEMENT OF HOTS METHOD IN BASKETBALL GAME THROUGH TGFU LEARNING

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Abstract

The study's purpose was to improve students' Higher Order Thinking Skills (HOTS) through learning using the Teaching Game For Understanding (TGfU) as a medium. This study uses purposive sampling with the provision of classes that have a low average value of physical education.

Materials and methods. This research is classroom action research (CAR). The sample used in this study consisted of one class totaling 32 students.

Results. The results of the study were that in the first cycle there were two assessments carried out, namely when playing the first game and the second game. In the first game students got a pretty good score, namely for the average SEI (Skill Execution Index) value of 0.72 from the highest score of 1 with a percentage of 72%, In the second cycle, the treatment given to students was still the same as the treatment in 1st cycle. In the second cycle, this time in the 1st game the average SEI value increased to 0.79 with a percentage of 79% then DMI increased to 0.81 with a percentage of 81% and the SI value increased to 0.81 with a presentation of 81%.

Conclusions. The learning process using TGfU can improve students' HOTS skills. Learning TGfU with attacking and defending games, can improve decision making, execution skills, and player support which can be seen from each indicator that is determined to have increased from each cycle carried out by students. Hopefully, this research can be a support for Physical Education to grow more advanced.

Keywords: teaching game, thinking skill, classroom action research, physical education.

Introduction

In teaching Physical Education (P.E.) and sporting activities, a directed engineering concept should be used (a technique-led approach) (Nasrulloh et al., 2021). The main purpose of using this approach is to help learners to be aware of the kinds of techniques required to play various sports activities. Students may be able to develop good techniques at various sporting abilities but have very little knowledge of the game. Giving learning experiences is done with multi-purpose, multi-method, multi-source and media by making students the subject of learning (Kristiyanto et al. 2020).

P.E. is one of the subjects in the 2013 curriculum. P.E. is an integral part of the national education program, aims to develop aspects of physical fitness, movement skills, critical thinking skills, social skills, reasoning, emotional stability, moral action, a healthy lifestyle and the introduction of a clean environment through the provision of learning experiences and carried out systematically based on the values of faith and devotion to God Almighty (Sutapa et al., 2020).

Creativity or the application of a knowledge of the ability to exercise to an alternative learning approach that can be applied. A response to claims that teaching games for understanding was not developed as a theoretically based pedagogical framework (Harvey et al., 2018). TGfU attracted the attention of all sports teachers. TGfU is an instruction model that focuses on developing the abilities of students (Wang, M., & Wang, L. 2018). Recent studies have tended to com-

pare or concentrate on the knowledge, psychological and affective outcomes of this approach (Gil-Arias et al., 2020). Research shows that tactics are more useful than approaches and their results support the development of new teaching theories in game-game teaching (Fani & Sukoco, 2019).

Low student achievement is not caused by a lack of abilities, but a lack of motivation to learn so that students do not direct all their abilities (Mandigo et al., 2019). For this reason, teachers are required to be more creative in the learning process starting from determining learning objectives, learning design, using learning media, and applying appropriate learning models, so that the expected learning objectives can be achieved properly. One of the strategies that teachers can do to achieve the desired learning objectives is to determine the learning media that suits their needs (Lodewyk & Bracco, 2018).

The learning model "tactical approach is a learning model that is often applied to sports games that emphasize understanding play tactics" (Barba-Martín et al., 2020). Learning sports games through a tactical approach can help students in making tactical and strategic decisions when playing games (Abad Robles et al., 2020). Learning games using a tactical approach model is an effective method of decision making in sports games, and should be used as the main goal in learning sports games (Gambles et al., 2018). Therefore, games are included as an important component in the physical education curriculum because it is better if 65% of physical education learning is more in the form of games (Gambles et al., 2018). More than 50% of the time spent in physical education programs at the School of Alberta is more directed towards learning games (Salimin et al., 2018).

The early recognition of this tactical approach was based on the findings of Bunker and Thorpe in 1982, through the concept of Teaching Game for Understanding (TGfU) (Memmert et al., 2015). In TGFU students learn a game that is directed to awareness of playing tactics and problems when tactical actions are taken. TGfU is designed to focus on developing tactical awareness and decision making with a framework of play or an appropriate form of play." Thus, when we apply a tactical approach to game learning, the TGfU concept must be embedded in the thinking of a physical education teacher. This pattern is illustrated in the sequence of learning games in the TGFU frame, namely (1) play, (2) game appreciation, (3) tactical awareness, (4) decision making, (5) skill implementation, (6) performance (Listyarini et al., 2021).

In TGFU, it is necessary to consider the need for knowledge and tactical understanding of a game, but many teachers prohibit the use of this model, especially in terms of providing material game and physical limitations. Consequently, the original TGfU was simplified into a three-level tactical approach (Tactical Games Approach / TGA) which focused on the three basic components in physical education lessons. The three components are: (1) modifying and simplifying the game, (2) developing awareness of tactics and solving problems through questions, and (3) developing skills such as individual motion using the ball and without the ball. Game modifications are designed or conditioned towards tactics in various game situations, such as defending the area or directing the ball to the target. All game conditions are always related to the rules, scoring methods, and objectives of the game, as well as providing the structure and purpose of the game. Learning the game through a tactical approach will get joy, excitement and motivation.

After studying several TGfU concepts described by several experts, and based on the opinion of Metzler and Housner (2009: 9) in Chapter I, it is known that the TGfU which was developed in England in the 1980s according to Griffin, Mitchell, and Oslin, the term is "Tactical Games Model (TGM)" (Armour et al. 2009). The Tactical Games Model (TGM) is the same as the Teaching Game Approach (TGA) which in the implementation of learning tends to refer to the relationship and the overall learning plan which includes: (1) theoretical basics, (2) statement of learning outcomes, (3) teacher knowledge skills, (4) develop adjustment and grouping of learning activities, (5) expect teacher and student behavior, (6) unique task structures, (7) assess learning outcomes, and (8) provide direction the model itself. There are three main assumptions in-game learning with a tactical approach, namely: (1) the game is modified in a representative manner to facilitate the form and conditions of the game (such as changes in game rules) which lead to tactical problems found in the game; (2) the game makes assessment easier; and (3) the game generally has a tactical problem, its basic form includes a classification system and a play tactic model structure. The classification system includes four main categories, namely (a) target play, (b) running / field games, (c) net games, and (d) invasion games.

The coaching process is a decision-making process in which the trainer is tasked with implementing the decisions that define practice. Training requires versatility because of the multitude of decision-making, including how to plan training sessions and training assignments. Training sessions, especially training assignments, mean developing abilities, or innate skills of players. Various studies have been conducted to assess how teaching and training of team sports are carried out through task analysis, with a major focus on the stages of sports initiation. From a non-linear pedagogical perspective, the analysis of the tasks for teaching and training sports designed by the coach is essential. This allows us to examine the context in which athletes learn (i.e. learning situations) and adapt to them sporting dynamics. Non-linear pedagogy characterizes the learning process in team sports as an unstable (non-linear) process, in which students must respond to the limitations and changes presented in learning situations with dynamic behavior and change according to the situation.

From a non-linear pedagogical perspective, there are proposals for the design of practice situations, based on ideas from Teaching Bunkers and Thorpe Games for Understanding (TGfU) in 1986, which were further developed by Mitchell and Oslin (2005). TGfU is highlighted as a teaching model for team sports from an alternative perspective. This model proposes the teaching of sports from the structure and understanding of the game itself, in which the development of athletes regarding tactics and decision making is given special importance. In line with this, during the exercise initiation stage, developing the athlete's cognitive skills is very important. Games with limitations and small games are the training tools and game situations proposed to teach team sports by the TGfU Model in the sports initiation stage. From the background above, this research has the aim of improving higher-order thinking skills or in other words, the High Order Thinking Skills (HOTS) of students through learning using the Teaching Games For Understanding (TGfU) method.

Materials and methods

Study participants

This research is a classroom action research (CAR). Data collection in this research was conducted at SMP Negeri 2 Godean, Sleman, Yogyakarta in November 2019. The participants in this study were students of class VII D at SMP Negeri 2 Godean. The sample used in this study consisted of one class totaling 32 students. Consisting of 20 female students and 12 male students. Sampling using purposive sampling with the provisions of the class that has a low average P.E. value.

Study organization

In this study, using 2 cycles to describe the improvement in the HOTS skills of students through TGfU learning. The research data collection technique used an observation sheet with the following criteria: 1). Decision making (decision making), the criteria for making decisions are: when doing offense students can make the right decisions when passing. Shoot when unable to pass a motion. Performs a layup when not guarded by the enemy. Meanwhile, when in defense, students can decide when to steal or grab the ball. 2). Skill execution (skill execution). The standard criteria used as criteria are: when students commit violations accurately, they reach the appropriate friend/recipient. Can print numbers. Meanwhile, when students can do intercepts appropriately. 3). Support (support). With the criteria when committing violations Students try to change positions to accept surgery from friends / open space to get surgery or perform screening. Meanwhile, when doing defense students are Keeping/ marking opponents who do not carry the ball.

Statistical analysis

The data analysis technique used in this study used descriptive analysis. Data analysis in this study was carried out by researchers and collaborators reflecting on the results of observations on the learning process carried out by the teacher and students in the classroom. The qualitative data in the field notes were processed into meaningful sentences and analyzed quantitatively. The data analysis technique is used sequentially, namely data reduction, data presentation, and conclusion drawing. Data reduction in this study includes selecting data through a summary or brief description and processing the data into a more targeted pattern. Thus data reduction is a form of analysis that sharpens, classifies, directs so that a verifiable conclusion can be drawn. In addition, this study also compares the suitability of the learning plan together with the collaborator that has been adjusted to the ongoing learning.

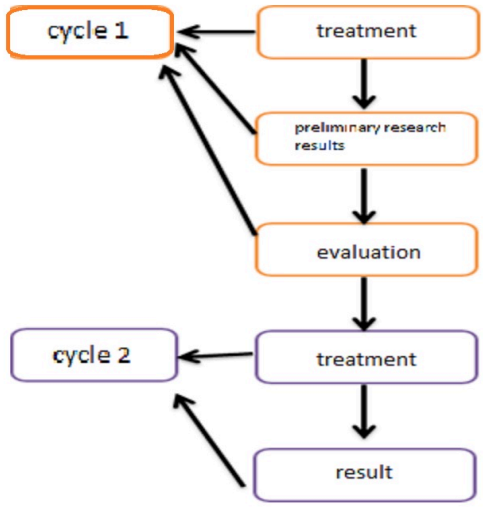

Figure 1. Research flow

Results

Cycle 1

In the first cycle, learning was carried out using the TGfU learning model through attack and defense games. Initially, the teacher divided students into groups consisting of groups of women and groups of men, each group consisting of 3-5 people according to the number of students. Learning is quite conducive and the teacher has also conveyed the stages of learning well, as evidenced by enthusiastic students during learning and experiencing progress in learning.

In this first cycle, two assessments were carried out, namely when working on the first game and the second game. In the first game, students get a pretty good score, namely for the average SEI score (skill implementation index) of 0.72 from the highest value of 1 with a percentage of 72%, then the average DMI (decision-making index) was 0.74 with a percentage of 74%, and the SI (support index) value was 0.76 with a percentage of 76%.

After doing the first game the teacher evaluates and takes the second measurement. From the second game, the increase in the increase of each of the following criteria: SEI reaches 0.75 with a percentage of 75% then DMI increases to 0.79 with a percentage of 79%, and the SI value increases to 0.79 with a percentage of 79%.

Thus the average student gets a good score for the meeting in this first cycle. However, because there are still some students who have unsatisfactory scores or below the desired KKM, which is 75 of the total scores. Then there will be evaluation and improvement in the second cycle.

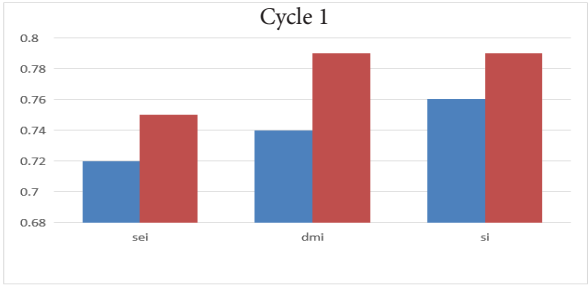

Figure 2. Diagram of games 1 and 2 in Cycle 1

Cycle 2

In the second cycle, the treatment given to students was still the same as the treatment in cycle 1. In the second cycle, this time in the first games, the average SEI score increased to 0.79 with a percentage of 79% then the DMI increased to

0.81 with a percentage 81%, and the SI value increased to 0.81 with a presentation of 81%.

In the second game, the teacher again gave evaluations to students and the result was an increase in all the assessment criteria. For the average SEI value increased to 0.82 with a percentage of 82%, then the IDM value increased to 0.83 or 83% and the SI value increased to 0.83 with a percentage of 83%. In this second cycle, the results can be seen and we can compare where from the first cycle to the second cycle there is a high enough difference from each of the predetermined criteria which we can see in the following graph:

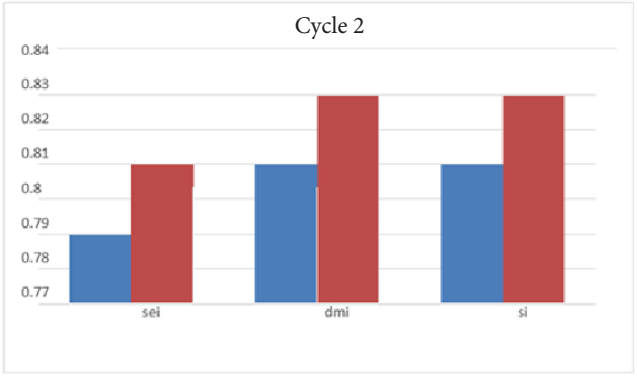

Figure 3. Diagram of games 1 and 2 in cycle 2

Based on these results, it can be compared to the results of cycle 1 and cycle 2, there is an increase in each learning carried out, thus learning using TGFU through an effective attack and defense games to improve children's cognitive abilities, especially the HOTS ability of the child.

Discussion

Based on the comparison of the results of cycle 1 and cycle 2, there was an increase in each lesson carried out, thus learning using TGfU through attacking and defending games was effective to improve students' cognitive abilities, especially the HOTS abilities possessed by these students. These results are in accordance with the research of Gil-Arias et al. (2021) that significant differences in student motivation were observed for both boys and girls who participated in the hybrid TGfU/SE unit in both analyses across all motivational outcomes. Furthermore, Batez et al. (2021) denoted that the effectiveness of the TGfU model of short duration (12 lessons) in an educational context to improve volleyball skills.

In addition, a research by Harvey et al. (2020) denoted that the effectiveness of the TGfU unit in developing adaptations to long-term memory that improved the quality of the students' tactical knowledge at all three levels of analysis (conceptualcontent, sophistication, and structure). the need to use pedagogical models such as TGfU to increase students' capacity to evaluate game situations and develop their tactical reasoning. Meanwhile, the research by Sierra-Ríos et al. (2020) claimed that TGfU seems to be more appropriate than direct instruction to increase the light PA levels during sessions while no significant differences were found between programs in moderate and vigorous intensities. Regarding the effects of programs in decisions, greater improvements in decisions with the ball were found in TGFU compared to DI.

By the end of the TGfU basketball unit, students modified the conceptual content of their tactical knowledge, as significant increases in their scores in all concepts, goals, conditions and predictions were observed. This increase in all concepts allowed students to have a greater capacity to reflect upon on executed actions and its influence on future actions. Moreover, a significant increase in conditions is important, because this shows that students generated specific advanced conditions to adapt and modify their interpretations of every game action over the course of the TGfU unit. Thus, students displayed a more in-depth tactical approach to the game situations they observed, continuously representing relevant information, which allowed them to explain how the players they observed would choose relevant skills to be executed (i.e. "if he cannot find one, he passes to his teammates or he just passes it off the wall"; "he charges for the ball when he has the chance to") (McPherson & Kernodle, 2007).

Likewise, these changes demonstrate that the students were more competent in modifying their interpretations of the game actions during each game play episode they observed, updating their action plan profiles (tactical action models faced with explicit conditions) and current event profiles (tactical condition prototypes used to take decisions), and referring to these profiles with an increasing level of complexity (McPherson, 2008). These changes in conceptual content lead to greater cognitive flexibility and greater capacity for participants to predict possible game events (i.e. "he knows when passes are going to be made to the other team"; "she anticipates that the other teammates is going to go into the direction towards their goals") that would help them select an effective response during game play (McPherson & Kernodle, 2007).

Regarding motor development through TGfU model studies González-Víllora et al. (2019), and Wang, M., and Wang, L. (2018), improved physical and physiological performance was shown, as well as levels of physical activity. Moreover, a novel study by García-González et al. (2020) showed that a hybrid Sports Education/TGfU volleyball teaching unit permits designing learning environments where students can make decisions and assume responsibilities, perceive themselves as skilled, and establish positive relationships with teammates. One more study by Broek et al. (2011) confirmed that an instructional model consisting of TGfU, sports education, cooperative learning and peer instruction with a determinant contribution of thoughtful decision-making skills might be key elements to create a powerful learning environment in which students can become self-regulated. The results from the current study by Barba-Martín et al. (2020) showed that the TGfU model improves not only the tactical knowledge but also the technical knowledge, which was confirmed by improved volleyball skills in our students. Therefore, our results and the results of the different studies highlight the TGfU as a positive pedagogical model in PE by promoting learning through understanding and knowledge, thus enjoying the fun of playing, which was confirmed in our study showing better enjoyment than PE classes.

Several limitations and future research directions should be considered. First, the small number of participants limits

the capacity to generalize the results. Consequently, future research can extend the current sample by, for example, increasing the number of students who complete the task in each class, and/or by using more PE classes/PE teachers at the same/different schools. Second, researchers did not include a control group to test the differences between groups. Therefore, it is not possible to guarantee that significant changes in tactical knowledge were a sole consequence of the TGfU unit. Third, only one TGfU unit has been developed in the current study. Consequently, it would be valuable to replicate this study and examine the effect on tactical knowledge over a more longitudinal time frame with the application of consecutive TGfU units in different team sports. Finally, future research could capture game performance data to link these data to student tactical knowledge development.

Conclusions

Based on the research result above, it can be concluded that learning using TGfU can improve students' HOTS skills. From TGfU learning through attack and defense games, it can improve decision making, skill execution, and player support, which can be seen from each determined indicator that has increased, from each cycle that is carried out.

There are many limiations in this research both in terms of time and existing facilities and infrastructure. Constructive suggestions are needed to build better research. It is hoped that after this research, there will be further researchers that develop Teaching Game for Understanding (TGfU), which will later build and open the gates of progress in the field of education in Indonesia to grow more advanced.

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Conflict of interest

All the authors of this research declare if there is no conflict of interest for this research.

References

Nasrulloh, A., Deviana, P., Yuniana, R., & Pratama, K. W. (2021). The Effect of Squat Training and Leg Length in Increasing the Leg Power of Volleyball Extracurricular Participants. *Teorìâ ta Metodika Fìzičnogo Vihovannâ,* 21(3), 244-252. https://doi.org/10.17309/tmfv.2021.3.08

Kristiyanto, A., Prasetyo, Y., Pratama, K. W., Karakauki, M., Mustapha, A., & Idrus, S. Z. S. (2020, April). Access to The Utilization of Science and Technology of Sports and Familiarity of the Sports Community towards Technologically Based Devices. *In Journal of Physics: Conference Series, 1529*(2), 022099. IOP Publishing. https://doi.org/10.1088/1742-6596/1529/2/022099

Sutapa, P., Prasetyo, Y., Pratama, K. W., Karakauki, M., Mustapha, A., & Idrus, S. Z. S. (2020, April). Motor Development Index (MDI) Based on Combination of Human Development Index (HDI) and Sport Development Index (SDI) as a Success Parameter of Motor Development among Preschool Children: An Observational Study. *In Journal of Physics: Conference Series, 1529*(3), 032003. IOP Publishing. https://doi.org/10.1088/1742-6596/1529/3/032003

Harvey, S., Pill, S., & Almond, L. (2018). Old wine in new bottles: a response to claims that teaching games for understanding was not developed as a theoretically based pedagogical framework. *Physical Education and Sport Pedagogy, 23*(2), 166-180. https://doi.org/10.1080/17408989.2017.1359526

Wang, M., & Wang, L. (2018). Teaching Games for Understanding Intervention to Promote Physical Activity among Secondary School Students. *BioMed research international,* 2018. https://doi.org/10.1155/2018/3737595

Gil-Arias, A., Claver, F., Práxedes, A., Villar, F. D., & Harvey, S. (2020). Autonomy support, motivational climate, enjoyment and perceived competence in physical education: Impact of a hybrid teaching games for understanding/sport education unit. *European Physical Education Review, 26*(1), 36-53. https://doi.org/10.1177/1356336x18816997

Fani, R. A., & Sukoco, P. (2019). Volleyball learning media using method of teaching games for understanding adobe flash-based. *Psychology, Evaluation, and Technology in Educational Research, 2*(1), 34-50. https://doi.org/10.33292/petier.v2i1.6

Mandigo, J., Lodewyk, K., & Tredway, J. (2019). Examining the impact of a teaching games for understanding approach on the development of physical literacy using the Passport for Life Assessment Tool. *Journal of Teaching in Physical Education, 38*(2), 136-145. https://doi.org/10.1123/jtpe.2018-0028

Lodewyk, K. R., & Bracco, E. (2018). Differences in Adaptive Outcomes between Previous Physical Education and a Teaching Games for Understanding Games Unit in Adolescent Girls. *ICHPER-SD Journal of Research, 10*(1), 12-20.

Barba-Martín, R. A., Bores-García, D., Hortigüela-Alcalá, D., & González-Calvo, G. (2020). The Application of the Teaching Games for Understanding in Physical Education. Systematic Review of the Last Six Years. *International Journal of Environmental Research and Public Health, 17*(9), 3330. https://doi.org/10.3390/ijerph17093330

Abad Robles, M. T., Collado-Mateo, D., Fernández-Espínola, C., Castillo Viera, E., & Giménez Fuentes-Guerra, F. J. (2020). Effects of Teaching Games on Decision Making and Skill Execution: A Systematic Review and Meta-Analysis. *International Journal of Environmental Research and Public Health, 17*(2), 505. https://doi.org/10.3390/ijerph17020505

Gambles, E. A., Anderson, S., Leyland, S., & Ling, J. (2018). *Barriers and Facilitators underpinning PE teachers' perspectives of the Teaching Games for Understanding approach using Occupational Socialisation.*

Gambles, E. A., Anderson, S., Leyland, S., & Ling, J. (2018). *Occupational Socialisation Theory: Identification of*

the barriers and facilitators that underpin physical education teachers' perspectives of the Teaching Games for Understanding approach.

Salimin, N., Noruzzaman, A. R., Shahril, M. I., Taff, M. A. M., & Ali, S. K. S. (2018, December). Students Reasoning Achievement Using Games Performance Assessment Instrument in Physical Education. *In 2nd Yogyakarta International Seminar on Health, Physical Education, and Sport Science (YISHPESS 2018) and 1st Conference on Interdisciplinary Approach in Sports* (CoIS 2018). Atlantis Press. https://doi.org/10.2991/yishpess-cois-18.2018.43

Memmert, D., Almond, L., Bunker, D., Butler, J., Fasold, F., Griffin, L., ... & Furley, P. (2015). Top 10 research questions related to teaching games for understanding. *Research quarterly for exercise and sport, 86*(4), 347-359. https://doi.org/10.1080/02701367.2015.1087294

Listyarini, A. E., Alim, A., Oktaviani, A. D., Putro, K. H., Kristiyanto, A., Margono, A., & Pratama, K. W. (2021). The Relations of Using Digital Media and Physical Activity with the Physical Fitness of 4th and 5th Grade Primary School Students. *Teorìâ ta Metodika Fìzičnogo Vihovannâ, 21*(3), 281-287. https://doi.org/10.17309/tmfv.2021.3.12

Armour, K. M., Makopoulou, K., Chambers, F., Housner, L. D., Metzler, M. W., Schempp, P. G., & Templin, T. J. (2009). The learning teacher in physical education. *In Historic traditions and future directions of research on teaching and teacher education in physical education.* https://doi.org/10.1016/j.tate.2011.10.006

Mitchell, S., & Oslin, J. (2005). Teaching games for understanding. *Standards-based physical education curriculum development,* 271-298.

Gil-Arias, A., Harvey, S., García-Herreros, F., González-Víllora, S., Práxedes, A., & Moreno, A. (2021). Effect of a hybrid teaching games for understanding/sport education unit on elementary students' self-determined motivation in physical education. *European Physical Education Review, 27*(2), 366-383. https://doi.org/10.1177/1356336x20950174

Batez, M., Petrušič, T., Bogataj, Š., & Trajković, N. (2021). Effects of teaching program based on teaching games for understanding model on volleyball skills and enjoyment in secondary school students. *Sustainability, 13*(2), 606. https://doi.org/10.3390/su13020606

Harvey, S., Gil-Arias, A., & Claver, F. (2020). Effects of teaching games for understanding on tactical knowledge development in middle school physical education. *Journal of Physical Education and Sport, 20*(3), 1369-1379.

Sierra-Ríos, J. V., Clemente, F. M., Rey, E., & González-Víllora, S. (2020). Effects of 6 weeks direct instruction and teaching games for understanding programs on physical activity and tactical behaviour in U-12 soccer players. *International Journal of Environmental Research and Public Health, 17*(14), 5008. https://doi.org/10.3390/ijerph17145008

McPherson, S. L., &Kernodle, M. W. (2007). Mapping two new points on the tennis expertise continuum: Tactical skills of adult advanced beginners and entry-level professionals during competition. *Journal of Sports Science, 25*(8), 945-959. https://doi.org/10.1080/02640410600908035

McPherson, S. L. (2008). Tactics: using knowledge to enhance performance. In D. Farrow, J. Baker, & C. MacMahon (Eds.), *Developing sport expertise: researchers and coaches put theory into practice* (pp. 155-167). London, UK: Routledge.

González-Víllora, S., Sierra-Díaz, M. J., Pastor-Vicedo, J. C., & Contreras-Jordán, O. R. (2019). The way to increase the motor and sport competence among children: the Contextualized Sport Alphabetization model. *Frontiers in physiology,* 10, 569. https://doi.org/10.3389/fphys.2019.00569

García-González, L., Abós, Á., Diloy-Peña, S., Gil-Arias, A., & Sevil-Serrano, J. (2020). Can a hybrid sport education/teaching games for understanding volleyball unit be more effective in less motivated students? An examination into a set of motivation-related variables. *Sustainability, 12*(15), 6170. https://doi.org/10.3390/su12156170

Broek, G. V., Boen, F., Claessens, M., Feys, J., & Ceux, T. (2011). Comparison of three instructional approaches to enhance tactical knowledge in volleyball among university students. *Journal of Teaching in Physical Education, 30*(4), 375-392. https://doi.org/10.1123/jtpe.30.4.375

УДОСКОНАЛЕННЯ МЕТОДУ HOTS У БАСКЕТБОЛЬНІЙ ГРІ ЧЕРЕЗ НАВЧАННЯ TGFU

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Реферат. Стаття: 7 с., 3 рис., 27 джерел.

Мета дослідження полягала в тому, щоб покращити навички мислення вищого порядку (HOTS) шляхом навчання з використанням навчальної гри для розуміння (TGfU) як засобу. У цьому дослідженні використовується цілеспрямована вибірка з наданням занять, які мають низьке та середнє значення фізичного виховання.

Матеріали та методи. Це дослідження є дослідженням дій у класі. Вибірка, використана в цьому дослідженні, складалася з одного класу загальною кількістю 32 учні.

Результати. Результати дослідження полягали в тому, що в першому циклі було проведено дві оцінки, а саме під час гри в першу гру та другу гру. У першій грі учні отримали досить хороший бал, а саме за середнє значення IBH (індекс виконання навичок) 0,72 від найвищого бала 1 з відсотком 72%. У другому циклі впливу, яке надавалося учням, все ще було так само, як і в 1-му циклі впливу. У другому циклі, цього разу в 1-й грі, середнє значення IBH зросло до 0,79 з відсотком 79%, потім індекс прийняття рішень зріс до 0,81 з відсотком 81%, а значення індекса підтримки зросло до 0,81 з відсотком 81%.

Висновки. Процес навчання з використанням TGfU може покращити навички HOTS студентів. Вивчення TGfU з атакуючими та захисними іграми може покращити прийняття рішень, навички виконання та підтримку гравців, що можна побачити з кожного показника, який, як визначено, зріс із кожного циклу, який виконували студенти. Сподіваємося, це дослідження може стати підтримкою розвитку фізичного виховання.

Ключові слова: навчальна гра, навичка мислення, дослідження дій у класі, фізичне виховання.

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ORIGINAL SCIENTIFIC ARTICLE

MORPHOFUNCTIONAL CHARACTERISTICS OF BASKETBALL PLAYERS WITH DIFFERENT ROLES AS SELECTION CRITERIA AT THE STAGE OF PREPARATION FOR HIGHER ACHIEVEMENTS

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Abstract

Objective. To study the morphofunctional characteristics of basketball players aged 17-20 years, taking into account their game role, and to substantiate the possibility of using them as criteria for selection and orientation at the stage of preparation for higher achievements.

Materials and methods. The study participants were 200 basketball players (17-20 years old). The following methods were used: theoretical analysis, pedagogical observation, pedagogical experiment with the use of instrumental methods of functional diagnostics (ergometry, chronometry, spirometry, gas analysis, and pulsometry), anthropometric methods, statistical methods.

Results. The study determined statistically significant differences in height and weight in all playing positions: the point guard is characterized by statistically significantly shorter body height compared to the shooting guard ($U = 46.5$; $z = -6.88$; $p < 0.01$), the shooting guard is statistically significantly shorter than the small forward ($U = 51.0$; $z = -5.58$; $p < 0.01$), the latter is shorter compared to the power forward ($U = 38.0$; $z = -5.56$; $p < 0.01$). The center was found to be statistically significantly taller than the power forward ($U = 82.0$; $z = 4.24$; $p < 0.01$). The model height indicators of centers at this stage of improvement are 205.9 ± 3.53 cm. Groups of athletes, depending on their roles, statistically significantly differ in body weight ($F = 64.304$; $p < 0.01$). Centers are the heaviest and point guards – the lightest basketball players. The dynamics of body height and weight indicators of basketball players from 16 to 20 years were determined.

Point guards and shooting guards have a statistically significantly higher level of VO_2max compared to centers and power forwards. The average level of VO_2max of players in the point guard position was 57.05 ± 3.78 ml·kg^{-1}·min^{-1}. In centers, this indicator is on average 49.10 ± 4.63 ml·kg^{-1}·min^{-1}. Centers had the VLC in the range of 9.38 ± 0.76 l, power forwards – 8.72 ± 0.80 l, defensive players – 7.5-8 l. No statistically significant differences were found in players with different roles in the level of AnT as a percentage of VO_2max.

Conclusions. Morphological and functional characteristics serve as informative criteria for monitoring the individual condition of players, are dynamic and can be used in different age groups, taking into account the specifics of team training and individual qualities.

Keywords: basketball, game position (role), training, morphological and functional criteria, selection.

Introduction

The specifics of the competitive activity in basketball require a distribution of game functions between players on the court. Modern basketball tends to universalize the capabilities of players, but complete unification of athletes' playing actions is impractical (Bezmylov et al., 2013). This is due to significant differences (anthropometric, functional, physical, etc.) between players who perform certain playing functions (Bavli, 2008; Dalextrat et al., 2009; Issurin, 2016).

According to Trninić et al. (2000), in order to perform the functions of all game roles on the court, it is necessary to satisfy the criteria of each of them, which is quite difficult. In basketball, anthropometric characteristics are crucial when distributing playing functions on the court (Cormery et al., 2008).

The dependence of successful competitive activity of certain basketball players on anthropometric characteristics is the cause of problematic issues that arise during the

training of basketball players in children and youth sports (Matulaitis et al., 2019). There are cases when a child starts playing basketball too late, at the age of 13-14, during a period of rapid growth (puberty) (Stroganov et al., 2020).

Taking into account good anthropometric characteristics, coaches enroll teenagers in a basketball section, despite the actual lack of basic training. Contradictions arise: teenagers are unable to catch up with their peers, who have more experience in basketball, in mastering and using the technical and tactical arsenal of game actions (Yixiong et al., 2019). In basketball, there are often cases where a player with good anthropometric qualities has a narrow range of playing possibilities on the court. In modern basketball, there are a lot of players with poor anthropometric characteristics (Erol et al., 2014). This explains coaches' interest in tall players, and the process of enrolling such athletes contradicts the general logic and rules of forming training groups in children and youth sports schools and private basketball clubs (Bezmylov et al., 2020a,b; Matulaitis et al., 2019).

The closer to the basket the player has to act, the more important the player's body height and weight are, allowing him/her to successfully fight and effectively attack the basket. And vice versa, the farther from the basket the athlete has to perform actions, the more important the player's speed capabilities, effective technique of movements, etc., become (Dalextrat & Cohen, 2009).

This issue is widely discussed by scientists and is important for basketball players at the stage of preparation for higher achievements. This determined the relevance of the study.

Objective. To study the morphofunctional characteristics of basketball players aged 17-20 years, taking into account their game role, and to substantiate the possibility of using them as criteria for selection and orientation at the stage of preparation for higher achievements.

Materials and Methods

Study participants

The study participants were basketball players of the youth national teams of Ukraine U 18 and U 20, players of the youth club team "Kyiv-Basket", who were at the stage of preparation for higher achievements (17-20 years old). A total of 200 players were examined.

Study organization

The study used the following methods: theoretical analysis, pedagogical observation, pedagogical experiment with the use of instrumental methods of functional diagnostics, morphological methods. The response of basketball players' cardiorespiratory system to aerobic and anaerobic exercise was studied in standardized laboratory conditions, using such methods as ergometry, chronometry, spirometry, gas analysis, and pulsometry. The ergospirometry complex "Oxycon Pro" (Jaeger, Germany) was used for gas analysis (Fig. 1).

Devices were calibrated automatically before and after testing each athlete. The error in registration of indicators was 0.02%. The composition and volume of the calibration mixture were 5% CO_2 and 17% O_2 in the N_2 balance (95%).

Test loads were performed on the LE-200 treadmill according to the standard program. Heart rate (HR, beats·min^{-1}) was measured using the "Sport Test Polar" RS 800 (Finland).

Fig. 1. Fragment of testing basketball players in laboratory conditions, using ergometry and gas analysis

The anaerobic threshold (AnT) was determined in the conditions of incrementally increasing exercise intensity in a non-invasive way, using the computer graphics analysis at the beginning of a non-linear increase in VE and VCO_2, the beginning of an increase in $VCO_2 \cdot VO_2$, and at the beginning of an increase in $EQCO_2$, which was not accompanied by a concomitant increase in $EQCO_2$, as well as at the beginning of an increase in the O_2 fraction in exhaled air (FEO_2,%). The study determined the point of anaerobic threshold and corresponding values of work intensity (WAnT), the time of achievement of AnT (PAnT), and other physiological indicators (VO_2 – AnT, VCO_2 – AnT, VE – AnT, HRAnT). Absolute and relative (in % of maximum) amount of O_2 consumption at the level of anaerobic threshold (VO_2 – AnT in % of VO_2max) was determined.

The indicators of body height (cm), weight (kg) were measured according to the standard. The subject was examined in a standard upright position. The study analyzed the peculiarities of manifestation of these indicators, taking into account the playing specialization of basketball players. The TANITA body analyzer (Japan) was used to determine the percentage of fat, muscle, and bone tissue of different body segments of basketball players. The study determined: body weight and height, percentage of fat in the body, trunk, and limbs – FAT %, fat mass in the body, trunk, and limbs – FAT MASS, kg, weight without fat in the body – FFM, kg, predicted muscle mass in the trunk and limbs – Predicted Muscle Mass (PMS), kg, total body water – TBW, kg, body mass index – BMI, and basal metabolic rate – BMR, kcal.

The study was conducted on the basis of the laboratory of the Research Institute of the National University of Physical Education and Sports of Ukraine.

Statistical analysis

The statistical analysis of data included verification of the observed data for normal distribution, using the Shapiro-Wilk test. If the indicators of basketball players in their role were normally distributed (such as body weight of athletes), the equality of variances of characteristics in comparison groups was assessed by the Levene's test and, since the conditions were met, comparative analysis of the indicators

was performed using the one-way ANOVA. The differences between the indicators in all groups were assessed using the Fisher's F-test, and pairwise comparisons – the Bonferroni test. In the case when the indicators did not meet the necessary conditions for using the one-way ANOVA (for example, the body height of athletes), its non-parametric analogue was used, namely the Kruskal-Wallis H test. Post hoc comparisons were performed with the help of the Mann-Whitney U test (Mann, Whitney, 1947; Byshevets, Denysova et al., 2019; Byshevets, Shynkaruk et al., 2019).

The value $\alpha = 0.05$ was taken as the level of statistical significance. Note that in the case when the calculated p-value was less than $1.0 \cdot 10^{-6}$, it was presented as $p < 0.01$. In other cases, the exact p-value is given.

Statistical processing of empirical data was implemented using the statistical analysis package STATISTICA 10.0 (StatSoft, USA).

Results

The analysis of the studied indicators of basketball players, who are at the stage of preparation for higher sports achievements, made it possible to determine model characteristics for each playing position. The indicators of young players of European championships (Spain, France, Lithuania, Serbia, Ukraine) were analyzed. Thus, the data on the body height and weight of basketball players were determined (Tables 1, 2). Statistically significant differences are observed between players of all roles.

Statistical analysis showed that not all indicators of the body height were normally distributed (The Shapiro-Wilk test ranged from 0.933 to 0.969, with p from 0.023 to 0.461), so to compare the body height of athletes, depending on their role, the study used the Kruskal-Wallis non-parametric test (see Table 1). It was found that H (4; 147) was 132.54, with $p < 0.05$, which indicates the statistical significance of differences between the body height of athletes, depending on their role.

The point guard is characterized by statistically significantly shorter body height compared to the shooting guard ($U = 46.5$; $z = -6.88$; $p < 0.01$) (see Table 1). The shooting guard is statistically significantly shorter than the small forward ($U = 51.0$; $z = -5.58$; $p < 0.01$), who is statistically significantly shorter compared to the power forward ($U = 38.0$; $z = -5.56$; $p < 0.01$). For his part, in contrast to the power forward, the center was found to be statistically significantly taller ($U = 82.0$; $z = 4.24$; $p = 2.3$ 10-5 < 0.01). It was proved that all groups of basketball players statistically significantly differ in the body height, depending on their role (Table 1, Fig. 2). Note that the model body height indicators of centers at this stage of improvement are on average 205.9 ± 3.53 cm.

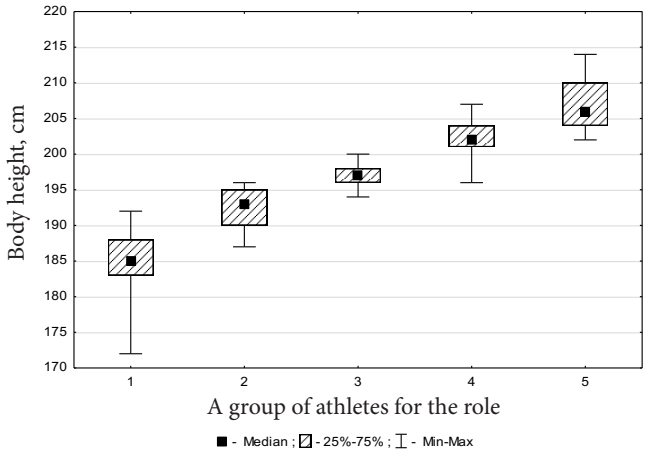

Fig. 2. Comparative analysis of the body height of athletes, depending on their role (n = 147), where 1 – point guard; 2 – shooting guard; 3 – small forward; 4 – power forward; 5 – center

All body weight indicators of basketball players were normally distributed ($0.929 \le W \le 0.972$; $0.104 \le p \le 0.515$), ANOVA was used to compare the body weight of athletes depending on their role (Table 2). Using the Levene's test, the study determined that the variances of athletes' body weight indicators do not differ statistically significantly ($F = 0.559$; $p = 0.693$), so the conditions for using the analysis of variance are met. Groups of athletes, depending on their roles, statistically significantly differ in body weight ($F = 64.304$; $p < 0.01$).

Table 1. Results of statistical analysis of the body height of basketball players, depending on their role (n=147)

Role	Calculated indicators				
	"Point guard" (n=39)	Shooting guard" (n=35)	"Small forward" (n=23)	"Power forward" (n=31)	"Center" (n=19)
	Average indicators: Me (25; 75)				
Body height, cm H (4, N = 147) = 132.54 p < 0.00001	185 (183;188)	193 (190; 195)	197 (196;198)	202 (201; 204)	206 (204; 210)
	Test of samples for normal distribution: W; p				
	0.9335; 0.02334	0.9335; 0.03556	0.9326; 0.12448	0.9690; 0.49111	0.9333; 0.19901
	Comparative analysis by the Mann-Whitney test		U	z	p
	PG-SG		46.5	-6.88	<0.00001
	SG-SF		51.0	-5.58	<0.00001
	SF-PF		38.0	-5.56	<0.00001
	PF-C		82.0	-4.24	0.00002

Table 2. Results of statistical analysis of the body weight of basketball players, depending on their role (n=147)

Role	Calculated indicators				
	"Point guard" (n=39)	**"Shooting guard" (n=35)**	**"Small forward" (n=23)**	**"Power forward" (n=31)**	**"Center" (n=19)**
Body weight, kg $F_{(4, 142)} = 64.304$, $p < 0.00001$	Average indicators: Me (25;75)				
	82 (74; 75)	87 (83; 935)	90 (85; 93)	100 (95; 103)	101 (99; 105)
	Test of samples for normal distribution: W; p				
	0.9497; 0.08033	0.9725; 0.51484	0.9289; 0.10359	0.9625; 0.33898	0.9518; 0.42412
	Comparative analysis by the Bonferroni test; Probabilities for Post Hoc Tests; Error: Between MS = 38.535, df = 142.00				
		"Point guard"	**"Shooting guard"**	**"Small forward"**	**"Power forward"**	**"Center"**
	PG		0.000042	0.000002	<0.00001	<0.00001
	SG	0.000042		1.000000	<0.00001	<0.00001
	SF	0.000002	1.000000		<0.00001	<0.00001
	PF	<0.00001	<0.00001	<0.00001		1.000000
	C	<0.00001	<0.00001	<0.00001	1.000000	

For post hoc comparisons, the Bonferroni test was used, the results of which showed statistically significant differences between the body weight of athletes in all groups, depending on their role (Fig. 3. See Table 2). Thus, centers are the heaviest and point guards are the lightest basketball players.

It was found that centers are significantly inferior to adult athletes in their anthropometric parameters (Table 3). The same differences are observed among power forwards. A comparison of the height and weight of basketball players by age – from 16 years and up to players of national teams, shows the biggest differences among basketball players of the offensive line.

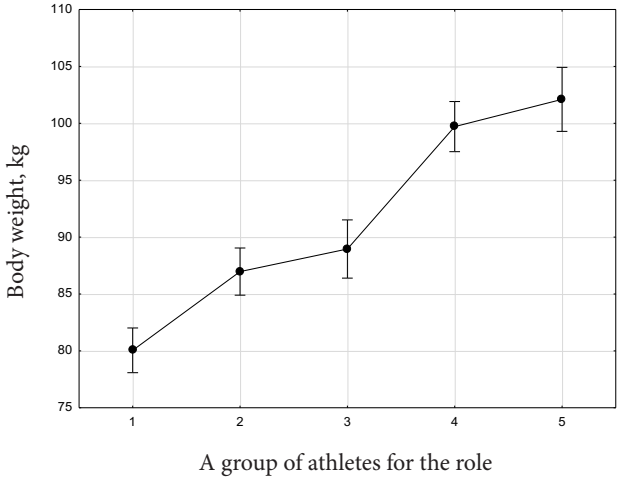

Fig. 3. Implementation of post hoc comparisons of the body weight of basketball players, depending on their game role in the STATISTICA 10.0 program, where vertical bars denote 0.95 confidence intervals

The study data on the functional capabilities of basketball players with different roles, who prepare for higher sports achievements, are presented in Table 4. The average level of VO_2 max in point guards was 57.05 ± 3.78 ml·kg·min^{-1}. The lowest VO_2 max values were found in centers – 49.10 ± 4.63 ml·kg·min^{-1}. In our study, the level of VO_2 max in players decreased linearly from the first to the fifth position.

During the step test, the highest values of maximum voluntary ventilation were recorded in power forwards, the lowest – in defensive players (point guards and shooting guards). During laboratory testing, the indicators of voluntary ventilation of power forwards reached the level of 166.25 ± 14.12 l·min^{-1}.

The highest values of intensity of the work performed during the test (W) were observed in point guards. The average level of maximum load during the step test was 357.50 ± 16.26 (W). During testing, the lowest intensity was achieved by centers – 315.50 ± 18.32 (W) (see Table 4).

There were no statistically significant differences between players with different roles in the level of AnT as a percentage of VO_2max. This indicator ranged from 70 to 90% of the level of VO_2max and characterized the player's individual level of fitness at the time of testing (Fig. 5). A similar situation was observed in the indicators of heart rate and exercise intensity in basketball players when reaching the AnT.

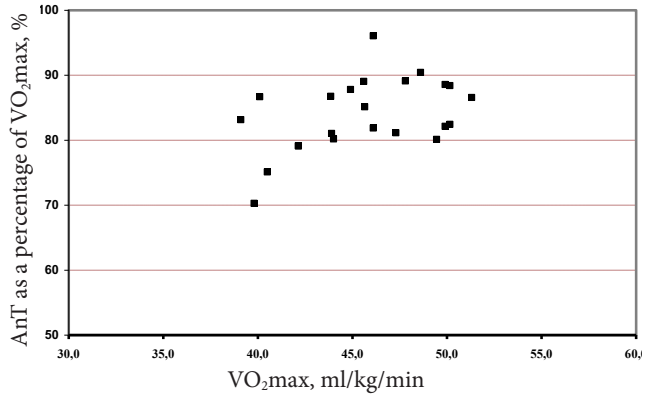

Fig. 4. Achievement of the anaerobic threshold (AnT) by basketball players aged 17-20 as a percentage of maximal oxygen consumption VO_2 max

Table 3. Dynamics of the body height indicators of basketball players, taking into account the age category at international basketball tournaments

No	Age	Point guard (n = 80) X ± s	p < 0.05	Shooting guard (n = 80) X ± s	p < 0.05	Small forward (n = 80) X ± s	p < 0.05	Power forward (n = 80) X ± s	p < 0.05	Center (n = 80) X ± s	p < 0.05
1	U 16	186.3±4.27	–	190.7±4.22	*4, 5, 6	196.4±3.60	4,5,6	201.3±3.93	4, 5, 6	203.6±3.34	2, 3, 4, 5, 6
2	U 17	186.4±4.93	–	192.0±5.26	5,6	196.5±3.88	6	202.0±3.21	5, 6	206.0±3.75	1,5,6
3	U 18	187.7±5.55	–	191.6±4.11	–	197.8±3.71	6	202.3±2.87	5, 6	205.9±3.53	1,5,6
4	U 19	187.2±6.64	–	194.6±4.85	1, 2	199.0±4.57	1	203.7±2.96	1, 6	206.9±3.34	1,6
5	U 20	187.1±5.60	–	194.5±3.44	1, 2	198.1±3.39	1	205.1±2.69	1, 2, 3	208.0±3.59	1,2,3,6
6	National Team	187.3±4.91	–	194.6±2.48	1, 2	199.1±8.42	1,2,3	205.1±7.05	1, 2, 3, 4	210.2±9.98	1,2,3,4,5

Note: * – differences with the corresponding number in the line of national teams are statistically significant, if p < 0.05

Table 4. Morphofunctional characteristics of basketball players at the stage of preparation for higher achievements, taking into account their game role (17-20 years)

No	Indicator	VO_2max $ml \cdot kg^{-1} \cdot min^{-1}$ X ± s	p < 0.05	Voluntary ventilation, $l \cdot min^{-1}$ (MVV) X ± s	p < 0.05	Vital lung capacity VLC, l X ± s	p < 0.05	Peak expiratory flow (PEF), $l \cdot s^{-1}$ X ± s	p < 0.05	Load, Wt X ± s	p < 0.05
1	Point guard	57.05±3.78	4, 5	144.55±12.83	4	7.54±1.02	4,5	11.10±1.18	3, 5	357.50±16.26	5
2	Shooting guard	55.60±3.02	5	141.70±16.87	4, 5	7.89±1.16	5	11.95±1.36	3, 5	325.14±36.51	–
3	Small forward	53.35±4.08	–	146.50±21.05	4	7.38±0.98	4,5	9.15±1.06	1, 2, 4	343.18±24.05	–
4	Power forward	52.95±3.65	1	166.25±14.12	1, 2, 3	8.72±0.80	1,3	11.68±1.92	3, 5	342.70±37.90	–
5	Center	49.10±4.63	1, 2	150.05±19.20	2	9.38±0.76	1,2,3	8.79±1.04	1, 2, 4	315.50±18.32	1

Note: * – differences with the corresponding role are statistically significant, if p < 0.05

Discussion

In team sports and basketball in particular, a characteristic feature of selection at the stage of preparation for higher sports achievements is the need to take into account the game specialization of athletes (Shynkaruk, 2011; Bezmylov et al., 2020; Kostiukevych et al., 2020, 2021). Players are selected for the team, taking into account the specific conditions of the competitive activity where the young player will perform playing functions on the court.

According to Bezmylov et al. (2013, 2020), the height of a basketball player increases linearly from the "first" to the "fifth" position. These differences are most significant between the players who perform the functions of the first (point guard) and the fifth (center) numbers on the court. As for other morphological features and the possibility of using them during sports selection, experts also pay attention to the athlete's wingspan, body composition, etc. (Apostolidis et al., 2004; Erol et al., 2014; Jeličić, 2002).

In the United States, when assessing the prospects of young basketball players in the NBA draft, the following morphological indicators of players are taken into account: bone length and width, sitting height of the player, chest circumference, body fat and muscle percentage, etc. (Yixiong et al., 2019; Bezmylov, Shynkaruk, & Murphy, 2020). These morphological indicators affect the competitive activity on the court. However, there are many examples (especially in women's basketball) when athletes do not meet the model anthropometric parameters, but effectively perform game actions on the court and counteract the opponent (Dalextrat & Cohen, 2009).

The structure of the competitive activity in basketball is complex, the final sports result is determined by a number of factors (player's level of mastery, game intuition, psychological qualities, etc.). Some morphological indicators, that are recommended as informative for determining the prospects of the player, are dynamic or can be actively corrected (body weight, fat-to-muscle ratio, etc.) (Abdelkrim et al., 2010; Matveyev, 1999; Ostojic et al., 2006).

The use of such morphological characteristics for sports selection at the stage of preparation for higher sports achievements is controversial, given that athletes at this stage (17-20 years old) continue to actively develop. In this regard, according to experts (Jeličić et al., 2002; Yixiong et al., 2019), body height is among the most informative morphological characteristics.

In the late 1980s and early 1990s, in the theory and practice of basketball, the division of players into five game roles – point guard, shooting guard, small forward, power forward, center – became widespread. For the first time, such a division of athletes was proposed in the NBA. Today, this division is unified and basic for many basketball countries around the world (Bezmylov, Shynkaruk, 2013; Sallet et al., 2005). This division of players is typical of elite sports.

During previous stages of long-term improvement, there are cases when the athlete focuses on two playing positions with further specification during the training process (Bezmylov et al., 2020).

With increasing body height (208 cm and above), the player is oriented mainly towards the functions of the fifth number (center), with stabilized indicators – the fourth number (power forward) (Yixiong et al., 2019).

Such temporary universalization in adjacent playing positions expands the possibility of using a tall player in subsequent performances in elite sports and minimizes strategic mistakes when choosing an athlete's playing position on the court. It was proved that the body height of the point guard from the age of 16 is quite stable. No statistically significant differences were found between young players (each category) and professional athletes ($p > 0.05$).

The analysis of the body composition of basketball players at the stage of preparation for higher sports achievements showed that almost all players have a low body fat level. This can be explained by the young age of athletes (17-20 years). Our data complement the findings of Ben Abdelkrim et al. (2007), which show that players of professional teams have statistically significantly higher levels of body fat in contrast to young athletes. We did not find any significant differences in body mass index between players performing different game functions on the court. Point guards and small forwards had an advantage, the differences are not statistically significant. In our opinion, this indicator and body mass index (conditional unit) are dynamic, depend on a number of factors, and can be considered auxiliary when monitoring players at the stage of preparation for higher achievements.

Our data showed that in the period from 16 to 20 years, the body height of power forwards and centers significantly changes, which must be taken into account during stage-by-stage determination of the final game specialization on the court. The difference between centers aged 16 and adult basketball players of national teams is 7-8 cm, and the difference in body weight can reach 20 kg and more. These differences are statistically significant ($p < 0.05$). When selecting young players, who are at the stage of preparation for higher achievements, coaches include them in the team on the line of attack (power forward and center) and allow players to perform both game functions.

Players who act mainly under the baskets must have a high level of speed and strength. Attacking players (power forward and center) use their own body size to gain an advantage in the fight for a favorable position when attacking the basket at a short distance, picking up the ball, or setting a screen. At this stage, when deciding on the selection of a player for the team and his/her subsequent orientation to a particular role in the game, height becomes dominant among morphological characteristics (Ostojic et al., 2006; Sallet et al., 2005).

The trend of modern basketball development is the intensification of competitive activity. This is due to the growing level of players' mastery, the use of modern technologies for training athletes, the change in the rules of FIBA competitions in 2000. This affected the game dynamics on the court. The time for an attack was reduced from 30 to 24 seconds, less time was allotted for throwing the ball out of one's half of the court, etc. (Abdelkrim et al., 2007; Cormery et al., 2008; Matulaitis et al., 2019). This affected the spectacularity of basketball matches: the game became faster, the requirements for the level of athletes' functional fitness increased.

Cormery et al. (2008) have long studied the functional capabilities of highly qualified basketball players from leading teams. A graphical comparison showed that the level of maximal oxygen consumption in basketball players who played in the mid-1990s was much lower than in athletes in the mid-2000s (after the introduction of new rules in 2000, which accelerated the dynamic characteristics of the game).

Bompa (2000), Lysenko (2010), Marinkovic et al. (2013) point out that the specifics of the competitive activity in basketball require a high level of both aerobic and anaerobic capacity. At the same time, according to scientists, it is the level of anaerobic capacity that becomes decisive for successful competitive activity in the game. Most of the competitive actions in the game are performed mainly in submaximal or maximal intensity zones. The average heart rate of players during technical and tactical actions (acceleration, jumps, throws, speed movement on the court, etc.) ranges from 85 to 95% of the maximum level (Abdelkrim et al., 2007; Marinkovic et al., 2013).

The specificity of the competitive activity structure in basketball is also determined by the intermittent nature of the game. High-intensity segments of the competitive activity alternate with periods of rest (during free throws, timeouts, rules violations, etc.), the duration of which roughly corresponds to the segments of the game (Yixiong et al., 2019). During short periods of rest (on average from 15 to 40 seconds), there is an active recovery of the athlete's body due to aerobic capacity (Abdelkrim et al., 2010; Bezmylov et al., 2013). After 2000, the time allotted for pauses in the game was significantly reduced. This led to increased requirements for the level of players' functional capabilities.

According to experts (Abdelkrim et al., 2007; Apostolidis et al., 2004; Lamontagne, 2013), defensive players must have the highest level of functional capabilities among other players. This is due to the specific conditions of functional responsibilities in the game. Defensive players have average and below average morphological qualities, but perform the majority of movements on the court during the game. The studies by Abdelkrim et al. (2007) and Apostolidis et al. (2004) show that in some cases, the level of VO_2max in elite basketball players, who play in defensive positions, reached 60-65 $ml \cdot kg^{-1} \cdot min^{-1}$. The lowest indicators of VO_2max were recorded in offensive players (center, power forward).

The study confirmed the data of Cormery (2008) on the intensification of competitive activity in modern basketball. The level of maximal oxygen consumption in skilled basketball players significantly increased (from 45-50 $ml \cdot kg \cdot^{-1} min^{-1}$ in the mid-1990s to 55-60 $ml \cdot kg \cdot^{-1} min^{-1}$ after the introduction of new rules in the 2000s).

In our study, the VO_2max of defensive players aged 17-20 years reached 60 $ml \cdot kg^{-1} \cdot min^{-1}$ in some cases during testing. The highest indicators of vital lung capacity (VLC) were shown by centers (9.38 ± 0.76 l) and power forwards (8.72 ± 0.80 l), which can be explained by the larger total size of their body compared to defensive players. Defensive players had a high level of VLC ranging from 7.5 to 8 l.

The peak expiratory flow during a forced spirometry, which characterizes the respiratory muscle strength, was identified as an informative indicator. A high level of peak expiratory flow was observed in defensive players and power

forwards ($p < 0.05$) compared to centers and small forwards. This indicator can be recommended to assess the functional fitness of young basketball players during the selection for teams to prepare for and participate in international competitions.

The obtained data confirm the opinions of experts (Abdelkrim et al., 2007; Apostolidis et al., 2004; Lamontagne, 2013) on different levels of fitness of young basketball players, taking into account their game role.

In the process of preparing national teams during four-six weeks, the basic functional training takes no more than two weeks. Athletes who start preparing for competitions in a national team in a better functional state due to individual basic training should be rated higher than others. The characteristics of assessing the level of a basketball player's functional capabilities have a significant reserve for the correction of training, but it is necessary to take into account a confluence of factors that affect the performance in team sports.

Conclusions

The study proved the importance of morphological and functional indicators for basketball players. The height indicators of power forwards and centers were found to be significant.

The determined morphological (height, weight, body composition) and functional characteristics (VO_2max, MVV, VLC, PEF, load intensity W, AnT) serve as informative criteria in the process of stage-by-stage and ongoing monitoring of the individual condition of players, are dynamic and can be used in different age groups, taking into account the specifics of training in a team and individually.

At the stage of preparation for higher achievements, the specifics of the competitive activity of basketball players with different roles put forward differentiated requirements for the level of their functional fitness.

Conflict of Interest

The authors declare no conflict of interest.

References

Bezmylov, N., & Shynkaruk, O. (2013). *Otsenka sorevnovatel'noy deyatel'nosti basketbolistov vysokogo klassa v igrovom sezone: monografiya*. K. 144 s.: il., tabl. Bibliografiya.: s. 139-143.

Bavli, Ö. (2008). Comparison the structural and biomotorical features of adolescent basketball players according to playing position. *Nigde University Journal of Physical Education and Sport Sciences, 2*(3).

Dalextrat, A., & Cohen, D. (2009). Strength, power, speed, and agility of women basketball players according to playing position. *Journal of Sports Strength & Conditioning Research, 23*(7), 1974-1981. https://doi.org/10.1519/jsc.0b013e3181b86a7e

Issurin, V. (2016). *Podgotovka sportsmena XXI veka. Nauchnyye osnovy i postroyeniye trenirovki.* M: Sport. 464 s.

Trninić, S., & Dizdar, D. (2000). System of the Performance Evaluation Criteria Weighted per Positions in the Basketball Game. Coll. *Antropol., 24*(1), 217-234.

Cormery, B., Marcil, M., & Bouvard, M. (2008). Rule change incidence on physiological characteristics of elite basketball players: A 10-year-period investigation. *British Journal of Sports Medicine,* (42), 25-30. https://doi.org/10.1136/bjsm.2006.033316

Matulaitis, K., Skarbalius, A., Abrantes, C., Gonçalves, B., & Sampaio, J. (2019). Fitness, technical, and kinanthropometrical profile of young Lithuanian basketball players aged 7-17 years old. *Frontiers in Psychology,* 10. Article 1677. https://doi.org/10.3389/fpsyg.2019.01677

Stroganov, S., Serhiyenko, K., Shynkaruk, O., Byshevets, N., Denysova, L., Yukhno, Yu., Stepanenko, O., & Ulan, A. (2020). Features of preventive activity at the initial stage of training of many years standing of young basketball players. *Journal of Physical Education and Sport, 20*(1), 66, 452-5. https://doi.org/10.7752/jpes.2020.s1066

Yixiong, C., Yixiong, C., Fuzheng, L., Dapeng, B., Haoyang, L., Shaoliang, Z., & Gomez, M.A. (2019). Key anthropometric and physical determinants for different playing positions during national basketball association draft combine test. *Frontiers in Psychology,* 10. Article 2359. https://doi.org/10.3389/fpsyg.2019.02359

Erol, E., Özen, G., & Koç, H. (2014). Selected Motor Skills of Elite Young Male Basketball Players According to Position on the Court of Players. *Journal of Athletic Performance and Nutrition, 1*(1), 1-9.

Bezmylov, M., Shynkaruk, O., & Murphy, T. (2020). Sports reserve training and selection of basketball players in the USA. *Theory and Methods of Physical education and sports,* 3, 10-20. https://doi.org/10.32652/tmfvs.2020.3.10–20

Bezmylov, N., Shynkaruk, O., & Zhigon, S. (2020). The selection peculiarities of basketball players at the specialized basic training stage. *Physical Education, Sport and Health Culture in Modern Society, 2*(50), 93-102. https://doi.org/10.29038/2220-7481-2020-02-93-102

Mann, H.B., & Whitney, D.R. (1947). On a test of whether one of two random variables is stochastically larger than the other. *Annals of Mathematical Statistics,* 18, 50-60. https://doi.org/10.1214/aoms/1177730491

Byshevets, N., Denysova, L., Shynkaruk, O., Serhiyenko, K., Usychenko, V., Stepanenko, O., & Syvash, I. (2019). Using the methods of mathematical statistics in sports and educational research. *Journal of Physical Education and Sport, 19*(3), 1030-34. https://doi.org/10.7752/jpes.2019.s3148

Byshevets, N., Shynkaruk, O., Stepanenko, O., Gerasymenko, S., Tkachenko, S., Synihovets, I., Filipov, V., Serhiyenko, K., & Iakovenko, O. (2019). Development skills implementation of analysis of variance at sport-pedagogical and biomedical researches. *Journal of Physical Education and Sport, 19*(6), 2086-90. https://doi.org/10.7752/jpes.2019.s6311

Shynkaruk, O.A. (2011). *Otbor sportsmenov i oriyentatsiya ikh podgotovki v protsesse mnogoletnego sovershenstvovaniya (na materiale olimpiyskikh vidov sporta): monografiya.* Kiev: Olympic literature. 360 s.

Kostiukevych,V., Lazarenko, N., Vozniuk, T., Shchepotina, N., Shynkaruk, O., Voronova, V., Borysova, O., Didyk,

T., Perepelytsia, O., Hudyma, S., & Bezmylov, N. (2020). Choice and experimental substantiation of tests for controlling physical and technical preparedness of hockey players. *Journal of Physical Education and Sport, 20*(5), 2735-744. https://doi.org/10.7752/jpes.2020.05372

Kostiukevych, V., Lazarenko, N., Shchepotina, N., Vozniuk, T., Shynkaruk, O., Voronova, V., Kutek, T., Konnov, S., Stasiuk, I., Poseletska, K., & Dobrynskiy, V. (2021). Factor Analysis of Special Qualities of Elite Field Hockey Players. *Sport Mont, 19*(S2), 41-47. https://doi.org/10.26773/smj.210908

Apostolidis, N., Nassis, G.P., Bolatoglou, T., & Geladas, N.D. (2004). Physiological and technical characteristics of elite young basketball players . *J Sports Med. Phys. Fitness,* 4, 157-163.

Jeličić, M., Sekulić, D., & Marinković, M. (2002). Anthropometric characteristics of high level European junior basketball players. *Collegium Antropologicum,* 26. 69-76.

Abdelkrim, B.N. Jabri, C., Battikh, I., El Fazaa, T. & El Ati, J. (2010). Activity profile and physiological requirements of junior elite basketball players in relation to aerobic-anaerobic fitness. *J Strength Cond Res.,* 24, 2330-2342. https://doi.org/10.1519/jsc.0b013e3181e381c1

Matveyev, L. (1999). *Osnovy obshchey teorii sporta i sistemy podgotovki sportsmenov.* Kiev: Olympic literature. 320s.

Ostojic, S.M., Mazic, S., & Dikic, N. (2006). Profiling in basketball: Physical and physiological characteristics of elite players. *The Journal of Strength &Conditioning Research, 20*(4), 740-744. https://doi.org/10.1519/00124278-200611000-00003

Sallet, P., Perrier, D., Ferret, J.M., Vitelli, V., & Baverel, G. (2005). Physiological differences in professional basketball players as a function of playing position and level of play. *The journal of sports medicine and physical fitness, 45*(3), 291-294.

Abdelkrim, B.N., Fazaa, S.E., & Ati, J.A. (2007). Time–motion analysis and physiological data of elite under-19-year-old basketball players during competition. *British Journal of Sports Medicine,* 41, 69-75. https://doi.org/10.1136/bjsm.2006.032318

Bompa, T. (2000). *Total Training for Young Champions.* Champaign, IL: Kinetics H, editor.

Lysenko, Ye. (2010). Osobennosti struktury funktsional'noy podgotovlennosti vysokokvalifitsirovannykh basketbolistov razlichnoy spetsializatsii. *Nauka v olimpiyskom sporte,* (1-2), 80-86.

Marinkovic, D., & Pavlovic, S. (2013). The differences in aerobic capacity of basketball players in different playing positions. *Physical Education and Sport, 11*(1), 73-80.

Lamontagne, A.M. (2013). *The Long-term development of basketball athletes.* [Dissertation]. Porto. Faculdade de desporto. Univeridade do Porto, 114.

МОРФОФУНКЦІОНАЛЬНІ ХАРАКТЕРИСТИКИ БАСКЕТБОЛІСТІВ РІЗНОГО АМПЛУА ЯК КРИТЕРІЙ ВІДБОРУ НА ЕТАПІ ПІДГОТОВКИ ДО ВИЩИХ ДОСЯГНЕНЬ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 4 табл., 4 рис., 29 джерел.

Мета досліджень. Дослідити морфофункціональні особливості баскетболістів 17-20 річного віку з урахуванням ігрового амплуа та обґрунтувати можливість їх використання як критерію відбору та орієнтації на етапі підготовки до вищих досягнень.

Матеріали і методи. В дослідженнях брали участь 200 баскетболістів (17-20 років). Використано теоретичний аналіз, педагогічне спостереження, педагогічний експеримент з використанням інструментальних методів функціональної діагностики (ергометрії, хронометрії, спірометрії, газоаналізу та пульсометрії), антропометричні методи, методи статистики.

Результати. Визначено статистично значущі відмінності за показниками росту та ваги за всіма ігровими позиціями: «Point guard» характеризується статистично значуще меншою довжиною тіла порівняно з «Shooting guard» ($U = 46,5$; $z = -6,88$; $p < 0,01$), «Shooting guard» відрізняється статистично значуще меншою довжиною тіла з «Small forward» ($U = 51,0$; $z = -5,58$; $p < 0,01$), той має меншу довжину тіла порівняно з «Power forward» ($U = 38,0$; $z = -5,56$; $p < 0,01$). «Center» виявився статистично значуще вищим від «Power forward» ($U = 82,0$; $z = 4,24$; $p = 2,3 \cdot 10^{-5} < 0,01$). Модельні показники росту центрових гравців на цьому етапі вдосконалення – 205,9 ± 3,53 см. Групи спортсменів залежно від амплуа статистично значуще відрізняються за масою тіла ($F = 64,304$; $p < 0,01$). Баскетболісти позиції «Center» мають найбільшу, а «Point guard» – найменшу масу тіла. Встановлено динаміку показників довжини та ваги тіла баскетболістів з 16 до 20 років.

Баскетболісти «Point guard» та «Shooting guard», мають статистично значуще більший рівень VO_2max у порівняні із «Center» та «Power forward». Середній рівень VO_2max гравців, що виступають на позиції «Point guard» склав – 57,05 ± 3,78 мл·кг·$^{-1}$хв$^{-1}$. У гравців «Center» цей показник в середньому на рівні – 49,10 ± 4,63 мл·кг·$^{-1}$хв$^{-1}$. Гравці позиції «Center» мали значення ЖЄЛ на рівні 9,38 ± 0,76 л, «Power forward» – 8,72 ± 0,80 л, баскетболісти лінії захисту – у діапазоні 7,5-8 л. Статистично значущих відмінностей не виявлено у гравців різного амплуа за рівнем досягнення ПАНО у відсотках від VO_2max.

Висновки. Морфологічні та функціональні характеристики слугують інформативними критеріями моніторингу за індивідуальним станом гравців, є динамічними та можуть використовуватися в різній віковій групі з урахуванням специфіки підготовки в команді та індивідуальних даних.

Ключові слова: баскетбол, ігрова позиція (амплуа), підготовка, морфологічні та функціональні критерії, відбір.

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ORIGINAL SCIENTIFIC ARTICLE

THE DIFFERENCE OF ANTHROPOMETRIC CHARACTERISTICS BETWEEN ELITE AND NOVICE BODYBUILDERS IN THAILAND

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Abstract

Research purpose. This study aim to compare anthropometric characteristics between elite and novice bodybuilders.

Materials and methods. Twenty bodybuilders consisted of 10 elites and 10 novices were recruited. Percent body fat, segmental lean mass, and segmental fat mass were measured by bioelectrical impedance analysis device. Other measure includes circumference of body segment and body height.

Results. Results of the study indicated that significant differences were found in term of upper arm (flexed) circumference, upper arm circumference, and chest circumference, with the elite were bigger than the novice. Elite bodybuilders also had significantly lower body fat percentage, with better segmental lean mass of right arm, left arm, and trunk. Interestingly neck, arm, waist, hip, thigh, and calf circumferences were not significantly different between groups. Similar insignificant differences were also found in body mass index, segmental lean mass of right leg and left leg, segmental fat mass of left and right arm, trunk, and left and right leg. With regards specifically to group of bodybuilders that participated in this study, the non-significant differences variables may indicated area that can be improved in term of training in both elite and novice. The variables with significant differences may indicate the area that may have been over-emphasize by the elite group, which may also contributed to their better (winning) performance.

Conclusions. As a conclusion, the results also corresponds well with bodybuilding judging criteria, where one of it such as size (circumference) may be similar, but bodybuilders with lean and well define body will be in the winning group.

Keywords: bodybuilding, anthropometry, lean body mass, balance, winning criteria.

Introduction

The science of anthropometric is the study of differences in the body variations in both athletic and general population. Anthropometric study could be performed by simple or high technology methods of data collection (Lee et al., 2019; Santos et al., 2004; Sterkowicz-Przybycień et al., 2011). It can be used for athletes' selection as coaches have to consider the basic body structure that suit with their sport and thus could contribute to the athletes' success in the future (Radu et al., 2015; WD et al., 1996). Some body composition has also been found to be correlated with physical fitness in athletes (Hoffman et al., 2018; Radu et al., 2014). At the same time, body compositions are very important for some sports. For example, bodybuilding in which the decision of winning or losing in the competition must be based on physical characteristics body proportions that meet the scoring and judging criteria.

Understanding differences or similarities between elite and novice level bodybuilders will be the fundamental basis for coaches and fitness trainers in prescribing appropriate physical training program. Typically the main reason for the elite group of athletes were classified as "elite" are when their sports specific performance is much higher than other group of athletes, with their performance experience is much longer (years of participation). However, certain part of their physical may or may not be similar to the begin-

ners. This may applies to anthropometry too. Bodybuilding competitions determine winning or losing mainly based on the size, muscularity, symmetry conditioning level of the muscle, posing ability and stage presentation (Gaines, 2001; Kardani & Rustiawan, 2020). Basic anthropometry of the bodybuilders thus becoming highly important, as the body will be trained into winnable characteristics with anthropometry as one of main factors that influence performance (Cevallos et al., 2017; Latella et al., 2019).

The method of measuring body composition in the component of body fat percentage, fat free mass, and mineral density in bodybuilders were studied in difference methods (Lichtenbelt et al., 2004). Girth measurement was also conducted to assess the change of body segment in bodybuilders as well (Hartgens et al., 2001; Kajaba et al., 1966). However, the body composition of an elite and novice bodybuilders, especially the details of body symmetry such as body fat percentage, lean mass, fat mass, and segmental circumferences which are important to the results of the competition has not yet been investigated. Therefore, the objective of this study is to investigate anthropometric characteristics between elite and novice bodybuilders.

Materials and methods

Study participants

The sample groups were recruited in this research consisted 10 Thai national bodybuilding athletes (Elite bodybuilders) (age 31.4 ± 7.34 years) with 10.20 ± 4.61 years of bodybuilding experience (3 world champion, 5 Asian champion and 2 Southeast Asia champion) and 10 new training bodybuilders (Novice bodybuilders) (age 22.2 ± 2.20 years) with 3.00 ± 0.81 years' experience in bodybuilding. All subjects had read the statement and signed inform consent prior participation in this study. This study was approved by the institute ethical review board of Chandrakasem Rajabhat University (No. 006/2563).

Instrumentation

Percent body fat, segmental lean mass, and segmental fat mass were measured by bioelectrical impedance analysis (BIA) technique using 50 kHz Accuinq model BC360 (Kim et al., 2018; Yang et al., 2018). Circumference of body segment was collected using measuring tape, with the body height was measured using stadiometer.

Data collection

Before standing on the foothold electrodes of each measuring device, the subjects' palms and soles were cleaned with electrolyte tissues; their ID, height, age, and gender were keyed in, and body weight was automatically calculated. They stood in an anatomical position for the measurement with their arms open and at an angle of about 30 degrees away from their body position was held until the end of the measurement, and, if not necessary, they were forbidden from speaking or moving during the process. Each calculation took approximately 2 minutes. After that, circumference measurement was conducted using girth measurement technique by Norton and Olds (1996).

Statistical Analysis

Data normality was analyzed using Shapiro – Wilk test before comparison of mean between groups. Descriptive statistics (mean and standard deviation) and inferential statistic (Independent t-test) were used to analyze the mean difference between the groups. Significant level was set at < 0.05.

Results

Table 1 showed the physical characteristics of both elite and novice bodybuilders involved as participants in this study. Elite bodybuilders age, weight, height and experience means were 31.40 ± 7.33 years, 81.33 ± 7.90 kg, 170.20 ± 7.23 cm, and 10.20 ± 4.61 years respectively. While novice bodybuilders were 22.20 ± 2.20 years, 77.27 ± 11.38 kg, 170.10 ± 5.76 cm, and 3.00 ± 0.81 years respectively.

Table 1. Characteristics of subjects

Characteristics	Elite bodybuilders		Novice bodybuilders	
	Mean	SD	Mean	SD
Age (years)	31.40	7.33	22.20	2.20
Weight (kg)	81.33	7.90	77.27	11.38
Height (cm)	170.20	7.23	170.10	5.76
Experience (years)	10.20	4.61	3.00	0.81

Table 2 showed the body composition data of both elite and novice bodybuilders. It can be seen that body fat percentage of elite bodybuilders (17.56 ± 3.70%) was significantly less than novice bodybuilders (20.99 ± 3.06%) at $p < 0.05$. While the segmental lean mass of right arm, left arm, and trunk of elite bodybuilders (4.28 ± 0.54 kg, 4.58 ± 0.72 kg, and 29.69 ± 3.37 kg) were significantly greater than novice bodybuilders (3.74 ± 0.41 kg, 3.79 ± 0.53 kg, 26.41 ± 3.05 kg) at $p<0.05$ respectively. However, body mass index, segmental lean mass of right leg and left leg, segmen-

Table 2. Body composition data of elite and novice bodybuilders

Variables	Elite bodybuilders		Novice bodybuilders		t	p
	Mean	SD	Mean	SD		
BMI (kg/m^2)	28.03	1.59	26.65	3.21	1.21	0.24
Percent Body Fat (%)	17.56	3.70	20.99	3.06	-2.25	0.03*
Segmental Lean Mass (kg)						
Right Arm	4.28	0.54	3.74	0.41	2.52	0.02*
Left Arm	4.58	0.72	3.79	0.53	2.78	0.01*
Trunk	29.69	3.37	26.41	3.05	2.27	0.03*
Right Leg	11.96	1.31	10.96	1.20	1.78	0.09
Left Leg	12.00	1.41	10.76	1.26	2.05	0.06
Segmental Fat Mass (kg)						
Right Arm	0.86	0.20	0.98	0.25	-1.22	0.23
Left Arm	0.84	0.20	0.99	0.25	-1.45	0.16
Trunk	7.28	1.54	8.37	2.04	-1.34	0.19
Right Leg	2.59	0.53	2.98	0.72	-1.38	0.18
Left Leg	2.62	0.55	2.98	0.71	-1.27	0.21

* Significant difference ($p < 0.05$)

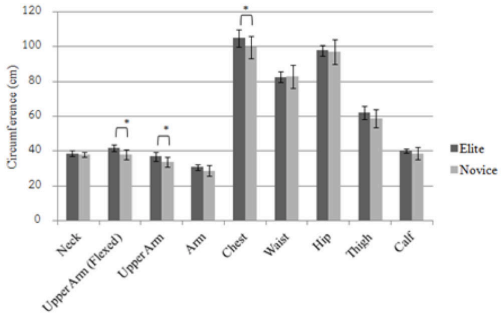

Figure 1. Body segment circumference

tal fat mass of left and right arm, trunk, and left and right leg were not significantly different between both groups.

Figure 1 showed the body segment circumference of both elite and novice bodybuilders. It was found that the upper arm (flexed) circumference, upper arm circumference, and chest circumference of elite bodybuilders (41.75 ± 1.84 cm, 37 ± 2.59 cm, and 104.95 ± 4.79 cm) were significantly greater than novice group (38 ± 2.66 cm, 33.9 ± 2.83 cm, and 99.75 ± 6.32 cm) at $p < 0.05$ respectively. However, neck, arm, waist, hip, thigh, and calf circumferences were not significantly different between groups.

Discussion

The aim of this study was to compare the anthropometric characteristics between elite and novice bodybuilders. In bodybuilding, it is the objectives of the athletes to develop lean body mass, muscle definition and good posing presentation. This lean body mass need to be symmetrical balanced in all parts.

Based on the World Health Organizations guidelines, it can be seen here that both elite and novice bodybuilders got more than 25 kg/m^2 of BMI, which mean that both groups are overweight. However, for this kind of sport, BMI cannot become the indicator in terms of their health risk. This is due to the BMI that is only based on body mass and weight, without taking care of what the mass is made up of. Consistently lifting weights will cause their muscle to grow and thus increase their mass. Thus, it is not shocking to for bodybuilders to have BMI of more than the normal level because some of study on body composition among bodybuilders higher than that level (Gaines, 2001; Lichtenbelt et al., 2004; Silva et al., 2003). For the comparison, it was found that the BMI is slightly higher for the elite group. This was obviously due to the body mass that is greater in elite group. To say the elite group to have more health risks is inappropriate, because it can be seen the elite group body mass is contributed by greater muscle mass while at the same time lesser fat percentage.

Next, we look at body fat percentage. It was found that elite group got significantly lower body fat percentage compared to the novice group. This is usual, as long term training will cause the fat percentage to drop. However, one of the main concern is the value of the body fat percentages. 17% for elite and 20% for novice are actually high for both athletes. This findings could be attributed to the current condition during data collection, which is during off-season due to the Covid-19 pandemic. Previous study has indicated that within 1-weeks prior competition, significant fat loss for desirable lean body by bodybuilders is achievable and typically done, thus making this percent of body fat acceptable during the time of this data collection (Bamman et al., 1993). Regardless of this, more study need to be conducted on the effects of Covid-19 pandemic to their training activities.

For the segmental lean mass, elite group possessed significantly greater right arm, left arm and trunk muscle mass. No significant differences in term of segmental lean mass of right leg and left leg. This could reflect on the need of extra upper body training for the novice bodybuilders. Asymmetrical value of overall body part or limbs is highly important for bodybuilding, and this study has clearly pinpoint one of the weaknesses within this group of bodybuilders, which is lack of asymmetry between upper and lower limb. This may be caused by over emphasized on upper limb during training. Over emphasized on upper limb or upper body abnormalities is not surprising among bodybuilders, which also known as upper cross syndrome as mentioned by Daneshmandi, Harati, and Fahim Poor (2017). A lot if training in years could differentiate the elite with the novice. But as clearly seen here, even the elite are in need to increase their lower limb training.

For the segmental fat mass is related to muscle definition. Elite bodybuilders were no significant differences of segmental fat mass of the left and right arm, trunk, and left and right leg when compare to novice group. It may effect from their similar training program during pandemic Covid-19. However, muscle definition phase need to be in the program before competition period. It is well known that to burn off fat as much as possible lead to improve muscle separation, striation, and definition (Bompa et al., 2012).

For the body segment circumference, it was found that the upper arm (flexed), upper arm, and chest circumference of elite bodybuilders were significantly greater than novice group but nearly elite bodybuilders in Brazilian on flexed biceps and calf circumference (Silva et al., 2003). Some segment circumference of elite group in this study was also found slightly greater than the study of Gaines (2001). Therefore, the elite group of bodybuilders would have a bigger proportion of their body segment, especially their upper body. Not only segment circumference, but also muscle definition and symmetry are another important factor that has been defined as a key bodybuilding competition factor (Gaines 2001). In novice group, the flexed biceps circumference and calf circumference of this study were lesser than beginning bodybuilders before and after three months of off-season period resistance training among beginning bodybuilders (Tykhorskyi et al., 2018). This is just another finding that is in line with the findings of segmental lean. More muscle mass means more size of the muscles, thus contribute to the more circumference. However, neck, arm, waist, hip, thigh, and calf circumferences were not significantly different between groups. This could be contributed to the fact that muscle at the neck, arm and waist has their own limitation to grow. For hip, thigh and calf, this is in line with what has been found at the segmental lean.

Conclusions

In conclusion, the perception is that elite bodybuilders will be having better significant differences with novice. But

the findings of this study indicated overall, the elite may have better body definition but lacking glaringly proper asymmetry similarly with the novice. Further studies are suggested to focus more on caused and solutions for the prevailing non-asymmetrical issues of bodybuilder's community, regardless of their seniority or level or participation.

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Conflict of Interest

The authors declare no conflict of interest.

References

Lee, Y.-C., Chen, C.-H., & Lee, C.-H. (2019). Body anthropometric measurements of Singaporean adult and elderly population. *Measurement,* 148, 106949. https://doi.org/10.1016/j.measurement.2019.106949

Santos, J., Albala, C., Lera, L., Garcia, C., Arroyo, P., Pérez-Bravo, F., Angel, B., & Peláez, M. (2004). Anthropometric measurements in the elderly population of Santiago, Chile. *Nutrition, 20*(5), 452-457. https://doi.org/10.1016/j.nut.2004.01.010

Sterkowicz-Przybycień, K. L., Sterkowicz, S., & Żarów, R. T. (2011). Somatotype, body composition and proportionality in polish top greco-roman wrestlers. *Journal of Human Kinetics,* 28, 141. https://doi.org/10.2478/v10078-011-0031-z

Radu, L.-E., Popovici, I.-M., & Puni, A.-R. (2015). Comparison of anthropometric characteristics between athletes and non-athletes. *Procedia-Social and Behavioral Sciences,* 191, 495-499. https://doi.org/10.1016/j.sbspro.2015.04.368

WD, W. N., Ismail, M., & Zawiah, H. (1996). Anthropometric measurements and body composition of selected national athletes. *Malaysian Journal of Nutrition, 2*(2), 138-147. https://nutriweb.org.my/mjn/publication/02-2/c.pdf

Radu, L.-E., Hazar, F., & Puni, A.-R. (2014). Anthropometric and physical fitness characteristics of university students. *Procedia-Social and Behavioral Sciences,* 149, 798-802. https://doi.org/10.1016/j.sbspro.2014.08.315

Hoffman, D., Robertson, S., Bourdon, P., Douglas, A., & Gastin, P. (2018). Anthropometric and physical fitness comparisons between Australian and Qatari male sport school athletes. *Asian Journal of Sports Medicine, 9*(3), 1-8. https://doi.org/10.5812/asjsm.59620

Gaines, R. P. (2001). *Comparison of anthropometric measures of competitive bodybuilders to judges' scores and a comparison of judges' scores.* Virginia Polytechnic Institute and State University. https://www.proquest.com/docview/304729718?pqorigsite=gscholar&fromopenview=true

Lichtenbelt, W. D. V. M., Hartgens, F., Vollaard, N. B., Ebbing, S., & Kuipers, H. (2004). Body composition changes in bodybuilders: a method comparison. *Medicine & Science in Sports & Exercise, 195*(9131/04), 3603-0490. https://doi.org/10.1249/01.MSS.0000117159.70295.73

Kardani, G., & Rustiawan, H. (2020). Circumference measurements on body contest athletes in Indonesia. *4th International Conference on Sport Science, Health, and Physical Education* (ICSSHPE 2019).

Cevallos, A. C. D., Pazmiño, S. M. A., Calderón, Á. F. Y., Velasco, W. F. S., & Morales, S. C. (2017). Anthropometry and maximum strength in bodybuilders. A study at the Army University-ESPE. *Revista Cubana de Investigaciones Biomédicas, 36*(1), 1-9. https://www.medigraphic.com/pdfs/revcubinvbio/cib-2017/cib171j.pdf

Latella, C., Van Den Hoek, D., & Teo, W.-P. (2019). Differences in strength performance between novice and elite athletes: Evidence from powerlifters. *The Journal of Strength & Conditioning Research,* 33, S103-S112. https://doi.org/10.1519/JSC.0000000000002823

Lichtenbelt, W. D. V. M., Hartgens, F., Vollaard, N. B., Ebbing, S., & Kuipers, H. (2004). Body composition changes in bodybuilders: a method comparison. *Medicine & Science in Sports & Exercise, 195*(9131/04), 3603-0490. https://doi.org/10.1249/01.MSS.0000117159.70295.73

Hartgens, F., Lichtenbelt, W. V. M., Ebbing, S., Vollaard, N., Rietjens, G., & Kuipers, H. (2001). Body composition and anthropometry in bodybuilders: regional changes due to nandrolone decanoate administration. *International Journal of Sports Medicine, 22*(03), 235-241. https://doi.org/10.1055/s-2001-18679

Kajaba, I., Zrubák, A., Grunt, J., Vavreková, A., Holecová, A., & Bučko, A. (1966). An anthropometric study applied to body-builders. *Anthropologie, 4*(3), 19-25. https://www.jstor.org/stable/26293736

Kim, M.-J., Kim, T.-Y., Choi, Y.-A., Chin, J.-H., & Lee, S.-Y. (2018). A study on the characteristics of standing posture of elderly women with sarcopenia in Korea. *Journal of Exercise Rehabilitation, 14*(3), 481. https://doi.org/10.12965/jer.1836060.030

Yang, S.-W., Kim, T.-H., & Choi, H.-M. (2018). The reproducibility and validity verification for body composition measuring devices using bioelectrical impedance analysis in Korean adults. *Journal of Exercise Rehabilitation, 14*(4), 621. https://doi.org/10.12965/jer.1836284.142

Norton, K., & Olds, T. (1996). *Anthropometrica: a textbook of body measurement for sports and health courses.* UNSW press.

Silva, P. R. P. d., Trindade, R. d. S., & De Rose, E. H. (2003). Composição corporal, somatotipo e proporcionalidade de culturistas de elite do Brasil. *Revista Brasileira de Medicina do Esporte,* 9, 403-407. https://doi.org/10.1590/S1517-86922003000600005

Bamman, M. M., Hunter, G. R., Newton, L. E., Roney, R., & Khaled, M. (1993). Changes in body composition, diet, and strength of bodybuilders during the 12 weeks prior to competition. *The Journal of Sports Medicine and physical Fitness, 33*(4), 383-391. https://europepmc.org/article/med/8035587

Daneshmandi, H., Harati, J., & Fahim Poor, S. (2017). Bodybuilding links to upper crossed syndrome. Physical Activity Review, 5, 124-131. https://doi.org/10.16926/par.2017.05.17

Bompa, T. O., Di Pasquale, M., & Cornacchia, L. (2012). *Serious Strength Training.* Human Kinetics.

Tykhorskyi, O., Dzhym, V., Galashko, M., & Dzhym, E. (2018). Analysis of the morphological changes in beginning bodybuilders due to resistance training. J*ournal of Physical Education and Sport,* 18, 382-386. https://doi.org/10.2478/v10078-011-0031-z

РІЗНИЦЯ АНТРОПОМЕТРИЧНИХ ХАРАКТЕРИСТИК МІЖ ЕЛІТНИМИ БОДІБІЛДЕРАМИ ТА ПОЧАТКІВЦЯМИ В ТАЇЛАНДІ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 5 с., 2 табл., 1 рис., 22 джерела.

Мета дослідження. Це дослідження спрямоване на порівняння антропометричних характеристик між елітними бодібілдерами та початківцями.

Матеріали та методи. У дослідженні брали участь двадцять бодібілдерів: 10 елітних і 10 новачків. Відсоток жиру в організмі, сегментарну худу масу та сегментарну масу жиру вимірювали за допомогою приладу для аналізу біоелектричного імпедансу. Інші показники включають окружність сегмента тіла та зріст тіла.

Результати. Результати дослідження показали, що були виявлені значні відмінності в термінах окружності плеча (згинання), окружності плеча та окружності грудей, при цьому елітні були більші, ніж новачки. Елітні бодібілдери також мали значно нижчий відсоток жиру в тілі, з кращою сегментарною худою масою правої руки, лівої руки та тулуба. Цікаво, що окружність шиї, рук, талії, стегон, стегон і литок істотно не відрізнялася між групами. Подібні незначні відмінності також були виявлені в індексі маси тіла, сегментарній м'язовій масі правої ноги та лівої ноги, сегментарній жировій масі лівої та правої руки, тулуба та лівої та правої ноги. Що стосується конкретно групи бодібілдерів, які брали участь у цьому дослідженні, то несуттєві відмінності змінних можуть вказувати на область, яку можна покращити в термінах тренувань як елітних спортсменів, так і новачків. Змінні зі значними відмінностями можуть вказувати на область, на якій, можливо, була надто акцентована елітна група, що також могло сприяти їх кращому (переможному) показнику.

Висновки. Результати відповідають критеріям оцінювання бодібілдингу, де один із них розмір (окружність), може бути схожим, але бодібілдери з худим і добре вираженим тілом будуть у групі-переможці.

Ключові слова: бодібілдинг, антропометрія, нежирна маса тіла, баланс, критерії виграшу.

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ORIGINAL SCIENTIFIC ARTICLE

FEATURES OF THE CANOEISTS' SPECIAL PHYSICAL FITNESS AT THE DISTANCE OF 1000 M

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Abstract

The aim of the study. To better understanding of the indicators of functional support for special endurance and physiological demands in canoeists at a distance of 1000 m.

Material and methods: 20 athletes (19-23 years) in canoeing from Shandong and Jiangxi provinces.

Results. According to the results of the analysis, the following typological groups of athletes-canoeists, specializing in the distance of 1000 m, with pronounced differences in the implementation of anaerobic energy supply. Typological groups of athletes had no significant differences in aerobic energy capacity ($p > 0.05$).

The first typological group (La max 90 s <10.08 mmol·l^{-1}, $p < 0.05$) is characterized by: power indicators 4.96 ± 2.35 mmol·l^{-1} and anaerobic energy supply capacity 6.93 ± 3.16 mmol·l^{-1}, which were the lowest among other groups of athletes. Athletes showed significantly low performance in 10-s, 30-s and 90-s tests, and performed less work in the step test, with varying degrees of severity of fatigue compensation mechanisms.

The second typological group (La max 90 s – 10.08-16.64 mmol·l^{-1}, $p < 0.05$), is characterized by high power 7.4 ± 1.68 mmol·l^{-1} and low capacity anaerobic energy supply 13.32 ± 1.52 mmol·l^{-1}. Athletes performed a sufficient amount of work in the step test (3-4 steps), but performance in the 90-s test was reduced, there were reduced characteristics of the ability to compensate for fatigue.

The third typological group (La max 90 s – > 16.64 mmol·l^{-1}, $p < 0.05$) is characterized by: power indicators 8.20 ± 2.36 mmol·l^{-1} and anaerobic energy supply capacity 17.85 ± 1.05 mmol·l^{-1}, which were the highest among other groups of athletes and significantly ($p < 0.05$) higher performance in 30 s, 90 s tests, and the level of power at which the maximum oxygen consumption in the step test is reached.

Conclusion. The results of the studies indicate differences in the level of functional support for special endurance for paddlers of uniform groups for canoeists that specialize in a distance of 1000 m.

Keywords: canoeing, aerobic energy supply, anaerobic energy supply, special performance.

Introduction

Canoeing and Kayaking are classified as event requiring mixed anaerobic lactic energy production, as well as great aerobic capacity and endurance; such reactions of energy production prevail in 1000 m event (Bishop, 2004; van Someren & Howatson 2008, Nekriošius et al., 2018). The typical individual performance times for men and women have been approximately 210 s for the 1000-m, respectively. At Rio 2016, medals won within 211.447 to 213.363 s, respectively, for 1,000 m.

During races, energy is supplied via the anaerobic and aerobic pathways (Garcia-Pallares, Sanchez-Medina et al. 2009), with aerobic metabolism contributing – 82 ± 5.0% for the 1000-m event (Lim et al., 1997).

Slow twitch, enduring muscle fibers with their inner intense aerobic processes are active participants in muscle work. In 1000 m event, good sport results are being achieved by athletes possessing relative maximal oxygen uptake 70 ml·min^{-1}·kg^{-1} (Nekriošius, 2018; Diachenko et al., 2020; Dy-

achenko, 2004) due to this fact, the significance and time allocation to aerobic capacity development for paddlers preparing for this event becomes obvious. Therefore, the training undertaken to prepare for such arduous activity is expected to develop several components of fitness, including maximum oxygen uptake ($V^{\cdot}O_2max$). The $V^{\cdot}O_2max$ is a common indicator for aerobic fitness and higher levels allow athletes to maintain higher power outputs and speed during racing. For example, investigations with athletes from national to elite international level have presented large-to-very large inverse correlations between $V^{\cdot}O_2max$ and performance over 1000-m on-water performance (Fry & Morton, 1991, Bishop, 2004; Bishop et al., 2002).

When overcoming the competitive distance of the 1000th, athletes row at 102% of the power of $V^{\cdot}O_2max$ (Zamparo et al., 1999). A study by individual authors (Tesch, 1983; Fry and Mortin, 1991; Bishop, 2004) demonstrated a high correlation between distance and $V^{\cdot}O_2max$, and power at the anaerobic threshold. Anaerobic power recorded during 30-second and 2-minute ergometer tests was also associated with kayak distance in kayakers (van Someren & Howatson, 2008).

Despite the fact that a number of studies have shown that the characteristics of the functional support of special performance have a wide range of individual differences, the issue of selection the typological features of the functional support of special performance of athletes who specialize in the distance of 1000 m in canoeing, were not the subject of special analysis. This leads to the selection of the problem issue that needs to be studied and analyzed.

The purpose of the study – identify differences and substantiate the typological features of the functional support of special performance of athletes who specialize in the distance of 1000 m in canoeing.

Materials and methods

Subject

Depending on the purpose of the research phase, the theoretical and experimental parts of the research were conducted at different training periods at the national aquatic sports training centers in Beihai, Zhizhao (PRC). The research involved 20 athletes (19-23 years) in canoeing from Shandong and Jiangxi provinces (PRC).

Research protocol

Physical Characteristics, Gas exchange, HR, and blood lactate measurements.

Minute ventilation ($V^{\cdot}E$), oxygen consumption ($V^{\cdot}O_2$), CO_2 production ($V^{\cdot}CO_2$), were determined on a breath-by-breath basis using an Oxycon mobile (Jaeger) metabolimeter. The metabolic unit was calibrated a gas of known composition (16.00% O_2, 4.00% CO_2), respectively.

HR was recorded every 5 s with an HR monitor (S610 Polar Electro, Kempele, Finland).

The blood lactate concentration ([La]b) was determined using a portable lactate analyzer (Biosen S. line lab +) on a blood sample obtained from the ear lobe at the end of the test.

A modified canoe-ergometer (Dansprint PRO, Denmark) was used. Ergometric power (EP) of work were recorded.

All the sportsmens performed an incremental exercise test on separate days, with at least 24 hours and no longer than 3 days between.

The testing program is built in the form of test battery, each test solving a task to assess certain component of anaerobic abilities of athletes and cardiorespiratory system response. Test tasks were performed in a strictly determined sequence. It was important to preserve the parameters of the ergometric power of work which provided for the energy release in anaerobic alactate and anaerobic lactate (glycolytic) way, as well as the length of the rest intervals. The rest interval between 10 and 30 s work was one minute, between 30 s and step test- seven minutes, between step test and 90 s – one minutes, after 90 s work – five minutes.

The composition of test tasks included the formed conditions of realization of structure of energy supply of rowers according to structure of special working capacity of rowers on competitive distance of 1000 m:

- "test 10 s" – the load forms the conditions for the realization of the start, taking into account the mobilization of power and capacity of anaerobic lactate energy supply. Indicator W 10 s, W is analyzed.
- "test 30 s"– the load forms the conditions for the realization of the capacity and capacity of anaerobic alactate and lactate (glycolytic) energy supply in accordance with the initial part of the competitive distance of 1000 m. Indicators W 30 s, W, La max 30 s, mmol·l^{-1} are analyzed.
- step-increasing load (step test): the first step is the ergometric power of work in accordance with the coefficient determined for men – canoe, at the level of 1.6 (coefficient × body weight). The increase in ergometric power on each step of work is 20 W, the duration of work on the step is 2 minutes. The work is performed to failure (inability to maintain ergometric power of work on the step). Features of functional training of qualified and especially highly qualified rowers for the kinetics of the cardiorespiratory system and aerobic energy supply. The load forms the conditions for the realization of body functions in terms of modeling the intensity of competitive activity. The period of reaching a steady state (Plateau) of consumption of O_2, W VO_2 max, VE/CO_2, VE/CO_2, VO_2 max c.u. are analyzed;
- critical power operation: acceleration for 90 s – "test 90 s". It is used to model the conditions of realization of power and capacity of anaerobic energy supply according to the second half of the distance of 1000 m against the background of increasing fatigue (performed one minute after performing the step-increasing test performed according to the VO_2 max registration protocol). Indicators W 90 s, W, La max 90 s, mmol·l^{-1}, VE/CO_2 90 s, c.u. are analyzed.

The research related to human use has complied with al the relevant national regulations and institutional policies; has followed the tenets of the Helsinki Declaration, and has been approved by the authors' institutional review board or al equivalent committee. Informed consent has been obtained from all individuals included in this study.

Statistical Analysis

The following methods of mathematical statistics were applied: descriptive statistics, selective method, Shapiro-

Wilk's normality test, non-parametric Mann-Whitney test. Methods of descriptive analysis were used, including tabular presentation of separate variables, calculation of mean arithmetic value (M), standard deviation (SD), coefficient of variation (CV, %). The sample data for normality were tested with the normal distribution formula and the Shapiro-Wilks test. The level of $p \leq 0.05$ (the probability of error) was assumed statistically significant.

Results

In the process of analyzing the experimental data, it was noted that the high value of the coefficient of variation of the anaerobic energy supply characteristics of the canoeists registered during the performance of the 30-second maximum test. Permissible limits exceeded the coefficient of variation (CV (%)>10-15 %, $p < 0.05$) recorded values of blood lactate concentration at the third minute of the recovery period and the maximum blood lactate concentration after performing a 30-second maximum test, were 26.05% and 26.27%, respectively for athletes in canoe.

The analysis also noted high values of the coefficient of variation of anaerobic energy supply characteristics of rowers registered during the 90-second maximum test, which simulated the conditions of realization of power and capacity of anaerobic energy supply according to the second half of the distance of 1000 m against increasing fatigue. Thus, the largest range of variation of 24.57% and the highest power of anaerobic energy reactions in canoeists were recorded during the 90-second maximum test, which simulated the conditions of increasing fatigue according to the second half of the distance of 1000 m.13.36 ± 3.28 mmol·l^{-1} and the range of differences of indicators – minimum and maximum 3.28-18.99 mmol·l^{-1}.

It should be noted the high range of variation of indicators that characterize the degree of compensation for fatigue (ratio of indicators VE/CO_2 VO_2 max, c.u. and VE/CO_2 90s, c.u.) In the period, performance of the step test and against the background of growing fatigue, in the 90-second test, and canoeists, which reached values of 76.39 %.

These differences indicate the possibility of distinguishing typological groups of canoeists with pronounced differences in terms of implementation of anaerobic energy supply at La max 90s< 10.08, La max 90s – 10.08-16.64 mmol·l^{-1}, La max 90 s – >16.64 mmol·l^{-1}. According to the results of the analysis, selected the following typological groups of athletes – canoeists, who specialize in the distance of 1000 m (table 1).

Table 1. Indicators of functional support of special working capacity of qualified canoeists who specialize in the distance of 1000 m (n=20), p<0,05

Indicators, values of indicators (M ± SD)	The first typological group La max 90 s <10.08 mmol·l^{-1} n = 2	The second typological group La max 90 s – 10.08-16.64 mmol·l^{-1} n = 15	The third typological group La max 90 s – >16.64 mmol·l^{-1} n = 3
Performance indicators			
W10s, W	190.5±30.41*	263.07±54.14	270.67±12.58
W30s, W	204.5±13.44*	256.47±28.58	275.33±25.15*
The amount of work in the step test, steps	1-2	3-4	2-4
W VO_2 max, W	121.5±14.85	141.0±15.67	156.33±13.58*
W 90 s, W	139.00±11.31	157.60±16.54	184.33±29.26*
Indicators of power and capacity of anaerobic energy supply			
La 3min 30 s, mmol·l^{-1}	4.96±2.35	6.62±1.41	8.03±2.5
La 7min 30 s, mmol·l^{-1}	4.59±2.12	7.30±1.7	8.17±2.32
La max 30 s, mmol·l^{-1}	4.96±2,35	7.4±1.68*	8.20±2.36*
Δ La 30 s, mmol·l^{-1}	-0.37±0.23	0.68±0.77	0.15±0.19
La 3 min 90 s, mmol·l^{-1}	6.93±5.16	12.76±1.38	17.27±1.72
La 5 min 90 s, mmol·l^{-1}	6.45±5.42	13.03±1.73	17.61±0.67
La max 90 s, mmol·l^{-1}	6.93±3.16	13.32±1.52*	17.85±1.05*
Indicators of aerobic energy supply capacity			
VO_2 max, ml·min^{-1}·kg^{-1}	53.11±2.20	51.83±5.44	55.73±7.46
Indicators, characterize the ability to compensate for fatigue			
VE/CO_2 VO_2 max*, c.u. .	28.5±0.71	31.13±5.57	31.33±5.69
VE/CO_2 90s **, c.u.	33.5±4.95	34.27±5.09	35.67±8.74

Notes: *-1 – indicators, registered at the starting point of achievement VO_2 max in "step test" (averages of 30 seconds); **-2 – indicators, registered in "test 90 s"

The first typological group characterized: significantly ($p < 0,05$) lower indicators of ergometric power in the conditions of increasing fatigue 139.00 ± 11.31 W (W90s, W), in the conditions of model of the starting segment of the distance 204.5 W (W30s, W), the indicators of ergometric power to achieve the level of maximum oxygen consumption in the conditions of step-increasing load were at the level of 121.5 ± 14.85 W (W VO_2 max, W) ,which were not significantly different from those of athletes in other typological groups ($p > 0.05$). Indicators of anaerobic energy supply capacity 6.93 ± 3.16 mmol·l^{-1} (La max 90 s) were the lowest among other groups of athletes. Differences in indicators are significant at $p < 0.05$. This group of athletes has an indicator of lactate concentration La max was registered at 3 minutes of the recovery period and by the seventh minute decreased by 1-0,04 mmol·l^{-1}. Indicators lactate kinetics has negative values. This group of athletes is characterized by different degrees of severity of fatigue compensation mechanisms.

The second typological group characterized: During the 90-second maximum test period, under the conditions of increased fatigue and difference in fatigue compensation, the aerobic energy supply index decreased, in some athletes VE/CO_2 VO_2 max c.u. exceeded VE/CO_2 90 s, c.u. Indicators of aerobic energy supply did not differ significantly from those of athletes of other typological groups ($p > 0.05$). Indicators of power and capacity of anaerobic energy supply 7.4 ± 1.68 mmol·l^{-1} (La max 30 s) and 13.32 ± 1.52 mmol·l^{-1} (La max 90 s) ($p < 0.05$) significantly exceeded the indicators of the first typological group.

The third typological group "Anaerobic" characterized: significantly higher indicators of ergometric power in conditions of increasing fatigue 184.33 ± 29.26 W (W90s, W), in the conditions of modeling of a starting segment of distance 275.33 ± 25.15 W (W30s, W), achieving the level of maximum oxygen consumption in the conditions of step-increasing load 156.33 ± 13.58 W (W VO_2 max, W), which were within the model range of high-class athletes ($p < 0.05$). This was taken into account that volume of step-increasing load, which was at the level of 2 to 4 steps. Indicators power 8.20 ± 2.36 mmol·l^{-1} (La max 30 s) and anaerobic energy supply capacity 17.85 ± 1.05 mmol·l^{-1} (La max 90 s) were the highest among other groups of athletes. Differences in indicators are significant at $p < 0.05$. Indicators power aerobic energy supply did not differ significantly from the performance of athletes of other typological groups ($p > 0.05$).

Discussion

Coaches and sport scientists must use valid and accurate instruments with equally valid and reliable protocols to detect training adaptations that could influence performance. Ergometers simulate the movement patterns of a sport, allowing access to the physiological responses in a controlled laboratory environment (van Someren, Phillips, & Palmer, 2000). The comparison of ergometer with on-water kayaking performance has concluded that kayak ergometers accurately simulate the physiological demands of short-term high-intensity kayaking (van Someren et al., 2000; van Someren & Palmer, 2002). The use of ergometers offers advantages in the evaluation of athletes performance in a laboratory context (Gomes et al., 2012), bringing advantages of methodological rigor in the control of athletes in the laboratory context.

The study (Coelho, et al., 2021). In conclusion, we found that $V{\cdot}O_2$max, stroke distance and stroke rate during the a maximal graded exercise test (GXT) were not different from the corresponding variables ($V{\cdot}O_2$peak, stroke distance and stroke rate) observed during the time-trial performance (TT), and that MAP and the corresponding stroke rate were strong predictors of 1,000 m TT performance. The results confirmed that $V{\cdot}O_2$max, chronological age, the speed at VT_1 and VT_2, stroke rate and power output are significantly correlated with the performance in a 1,000 m time-trial. This study demonstrated that in well-trained young kayakers, cardiorespiratory fitness could be assessed during a time-trial test that mimics the actual performance attained in flat water.

The lactate concentration values found in this study highlights the contribution of the anaerobic energy pathway to kayak TT performance and reinforces the role of the significant contribution of anaerobic energy sources in sprint kayak performance (Gomes et al., 2012).

Previous research did not report the verified correlation of the velocity at VT_1 and VT_2 intensities with that of 1,000 m. These results support the importance of the aerobic-fitness variables as a valuable and useful marker for monitoring longitudinal athlete development and. They could also reinforce that better submaximal (velocity) performance influences the all-out time-trial performance. The relative intensity of VT_1 and VT_2 found in study Coelho et al. (2021).

The findings López-Plaza et al. (2017, 2018), Alacid and Carrasco (2004) confirm the importance of maturity status in sprint kayaking and canoeing since the more mature paddlers were also those who revealed largest body size, physical fitness level and best paddling performance. Additionally, the most important variables predicting performance times in kayaking and canoeing were maturity status and chronological age, respectively. Negative and significant correlations ($p < 0.01$) were detected between performance times, chronological age and anthropometry (body mass, height, sitting height and maturity status), overhead medicine ball throw and sit and reach for all distances.

In the beginning of the preparation for the season 2011 was carried out testing with incrementally increasing power loads capacity (4×3 min, with 1-minute interval) on the ergometer "Dansprint" with the kayakers of national team of the Republic of Belarus (n = 27). On the last step was measured the work and was calculated the amount of ATP which is necessary for it accomplishment. Based on the data of kinetics of lactate concentration in the blood before the beginning of rowing on the last step and during the recovery period was revealed the rate constant of disappearance and appearance of lactate in the blood. It allowed to calculate the maximum lactate concentration in the compartment within the absorption of one-compartment pharmo-kinetics' model. Taking into account its volume, were determined the number of the formed lactate and ATP resynthesizing as a results of anaerobic glycolysis (1.03 (0.90-1.19) mol – men, 0.48 (0.39-0.61) mol – women) and the contribution of latter in the energy supply of exercise – 31 (26-34)% and 22 (22-25)% (Moroz et al., 2016; Kong Xianglin et al., 2019, 2020).

Therefore, coaches can use these variables ($V{\cdot}O_2$max, chronological age, the speed at VT_1 and VT_2, stroke rate and power output) as performance markers when monitor-

ing their athletes with regards to predictive factors of sport-specific performance. Programming training to improve these variables may therefore also improve 1,000-m kayaking performance.

Conclusions

According to the results of experimental research, substantiated the differences and typological features of the functional support of the special performance of athletes who specialize in the distance of 1000 m in canoeing.

According to the results of the analysis, the following typological groups of athletes-canoeists, specializing in the distance of 1000 m, with pronounced differences in the implementation of anaerobic energy supply.

The first typological group (La max 90s <10.08 mmol·l^{-1}, $p < 0.05$) is characterized by: power indicators (La max 30 s) 4.96 ± 2.35 mmol·l^{-1} and anaerobic energy supply capacity (La max 90 s) 6.93 ± 3.16 mmol·l^{-1}, which were the lowest among other groups of athletes. Athletes showed significantly low performance in 10-s, 30-s and 90-s tests, and performed less work in the step test, with varying degrees of severity of fatigue compensation mechanisms.

The second typological group (La max 90s – 10.08-16.64 mmol·l^{-1}, $p < 0.05$), is characterized by high power (La max 30 s) 7.4 ± 1.68 mmol·l^{-1} and low capacity anaerobic energy supply (La max 90 s) 13.32 ± 1.52 mmol·l^{-1}. Athletes performed a sufficient amount of work in the step test (3-4 steps), but performance in the 90-s test was reduced, there were reduced characteristics of the ability to compensate for fatigue.

The third typological group (La max 90 s> 16.64 mmol·l^{-1}, $p < 0.05$) is characterized by: power indicators (La max 30 s) 8.20 ± 2.36 mmol·l^{-1} and anaerobic energy supply capacity (La max 90 s) 17.85 ± 1.05 mmol·l^{-1}, which were the highest among other groups of athletes and significantly ($p < 0.05$) higher performance in 30-s, 90-s tests, and the level of power at which the maximum oxygen consumption in the step test is reached.

Typological groups of athletes had no significant differences in aerobic energy capacity ($p > 0.05$). Thus, these data form the basis for a specialized focus of the training process of athletes of different typological groups.

Prospects for further research consist in the implementation of the developed theoretical provisions to the management system of training and competitive loads of athletes in canoeing.

Conflict of Interest

The authors declare no conflict of interest.

References

Bishop, D. (2004). The validity of physiological variables to assess training intensity in kayak athletes. *International journal of sports medicine, 25*(1), 68-72. https://doi.org/10.1055/s-2003-45233

Someren, K. V., & Howatson, G. (2008). Prediction of flatwater kayaking performance. *International journal of sports physiology and performance, 3*(2), 207-218. https://doi.org/10.1123/ijspp.3.2.207

García-Pallarés, J., Sánchez-Medina, L., Carrasco, L., Díaz, A., & Izquierdo, M. (2009). Endurance and neuromuscular changes in world-class level kayakers during a periodized training cycle. *European journal of applied physiology, 106*(4), 629-638. https://doi.org/10.1007/s00421-009-1061-2

Bishop, D., Bonetti, D., & Dawson, B. (2002). The influence of pacing strategy on VO_2 and supramaximal kayak performance. *Medicine and science in sports and exercise, 34*(6), 1041-1047. https://doi.org/10.1097/00005768-200206000-00022

Nekriošius, R., Dadeliene, R., , Balčiūnas, E., & Milasius, K. (2018).Peculiarities of aerobic development in kayak rowers preparing for 1000 m event. *Baltic Journal of Sport and Health Sciences,* 3. https://doi.org/10.33607/bjshs.v3i90.167.

Lim, A. C., Byrnes, W. C., Wilber, R. L., & Kearney, J. T. (1997). Exercise-induced desaturation in elite female and male cyclists at moderate altitudes 1628. *Medicine & Science in Sports & Exercise, 29*(5), 286. https://doi.org/10.1097/00005768-199705001-01627

Diachenko, A., Guo Pengcheng, Wang Weilong, Rusanova, O., Kong Xianglin, & Shkrebtiy, Y. (2020). Characteristics of the power of aerobic energy supply for paddlers with high qualification in China. *Journal of physical education and sport, 20*(supplement issue 1), art 43, 312-317. https://doi.org/10.7752/jpes.2020.s1043

Dyachenko, A.Y. (2004). *Special endurance of qualified athletes in rowing.* NPF Slavutich-Dolphin. 338 p.

Fry, R. W., & Morton, A. R. (1991). Physiological and kinanthropometric attributes of elite flatwater kayakists. *Medicine and science in sports and exercise, 23*(11), 1297-1301. https://doi.org/10.1249/00005768-199111000-00016

Zamparo, P., Capelli, C., & Guerrini, G. (1999). Energetics of kayaking at submaximal and maximal speeds. *European journal of applied physiology and occupational physiology, 80*(6), 542-548. https://doi.org/10.1007/s004210050632

Tesch P. A. (1983). Physiological characteristics of elite kayak paddlers. Canadian journal of applied sport sciences. *Journal canadien des sciences appliquees au sport, 8*(2), 87-91.

Someren, K. V., Phillips, G. R., & Palmer, G. S. (2000). Comparison of physiological responses to open water kayaking and kayak ergometry. *International journal of sports medicine, 21*(3), 200-204. https://doi.org/10.1055/s-2000-8877

Someren, K. V., & Palmer, G. S. (2003). Prediction of 200-m sprint kayaking performance. *Canadian journal of applied physiology, 28*(4), 505-517. https://doi.org/10.1139/h03-039

Someren, K.V., & Howatson, G. (2008). Prediction of flatwater kayaking performance. *International journal of sports physiology and performance, 3*(2), 207-18. https://doi.org/10.1123/ijspp.3.2.207

Gomes, B. B., Mourão, L., Massart, A., Figueiredo, P., Vilas-Boas, J. P., Santos, A. M., & Fernandes, R. J. (2012). Gross efficiency and energy expenditure in kayak ergometer exercise. *International journal of sports medicine, 33*(8), 654-660. https://doi.org/10.1055/s-0032-1301907

Coelho, A. B., Nakamura, F. Y., Morgado, M. C., Alves, F., Di Baldassarre, A., Flatt, A., & Rama, L. (2021). Prediction of Simulated 1,000 m Kayak Ergometer Performance in Young Athletes. *Frontiers in public health,* 8, 526477. https://doi.org/10.3389/fpubh.2020.526477

López-Plaza, D., Alacid, F., Muyor, J. M., & López-Miñarro, P. Á. (2017). Sprint kayaking and canoeing performance prediction based on the relationship between maturity status, anthropometry and physical fitness in young elite paddlers. *Journal of sports sciences, 35*(11), 1083-1090. https://doi.org/10.1080/02640414.2016.1210817

López-Plaza, D., Alacid, F., Rubio, J.Á., López-Miñarro, P.Á., Muyor, J.M., & Manonelles, P. (2018). Morphological and physical fitness profile of young female sprint kayakers. *J Strength Cond Res.,* 14. https://doi.org/10.1519/jsc.0000000000002511

Alacid, F., & Carrasco, L. (2004). Distribución del esfuerzo en piragüismo sobre 1000 metros. *III Congreso de la Asociación Española de Ciencias del Deporte, Universidad de Valencia.* Valencia. https://doi.org/10.33262/cde.4

Moroz, E.A., Shantarovich, V.V., & Shkumatov L.M. (2016). Assessment of the role of anaerobic glycolysis in energy supply of the testing physical load of redgears on high qualification kaids at the initial stage of annual training. *Applied Sports Science, 2*(4), 74-80.

Kong Xianglin, Guo Pengcheng , Wang Weilong , Rusanova, O., & Diachenko, A. (2020). Planning special physical training for rowers in China: a randomized study. *Journal of Physical Education and Sport, 20*(4), Art 229, 1688-1694. https://doi.org/10.7752/jpes.2020.04229

Kong Xianglin, Guo Pengcheng, Rusanova, O., & Diachenko, A. (2019). Reaction of the organism to repeated training loads, directed to improve the performance of the qualified rowers of China. *Journal of Physical Education and Sport, 19*(Supplement issue 2), Art 66, 453-460. https://doi.org/10.7752/jpes.2019.s2066

ОСОБЛИВОСТІ ФУНКЦІОНАЛЬНОГО ЗАБЕЗПЕЧЕННЯ СПЕЦІАЛЬНОЇ ПРАЦЕЗДАТНОСТІ КАНОЇСТІВ, ЯКІ СПЕЦІАЛІЗУЮТЬСЯ НА ДИСТАНЦІЇ 1000 м

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Реферат. Стаття: 5 с., 1 табл., 22 джерела.

Мета дослідження. Визначити відмінності функціонального забезпечення спеціальної працездатності каноїстів, які спеціалізуються на дистанції 1000 м.

Матеріал і методи: 20 спортсменів (19-23 роки) з веслування на каное з провінцій Шаньдун і Дзянсі.

Результати. За результатами аналізу виділяють наступні типологічні групи спортсменів-каноїстів, що спеціалізуються на дистанції 1000 м, із вираженими відмінностями у здійсненні анаеробного енергозабезпечення. Типологічні групи спортсменів не мали достовірних відмінностей за показниками потужності аеробного енергозабезпечення ($p > 0,05$).

Перша типологічна група (La max 90-с <10,08 ммоль·л$^{-1}$, $p < 0,05$) характеризується: показниками потужності 4,96 ± 2,35 ммоль·л$^{-1}$ та ємності анаеробного енергозабезпечення 6,93 ± 3,16 ммоль·л$^{-1}$, які були найнижчими серед інших груп спортсменів. Спортсмени показали достовірно низькі результати в 10 с, 30 с і 90 с тестах, а також виконували менше роботи в степ-тесті з різним ступенем вираженості механізмів компенсації втоми.

Друга типологічна група (La max 90 с – 10,08-16,64 ммоль·л$^{-1}$, $p < 0,05$), характеризується високою потужністю 7,4 ± 1,68 ммоль·л$^{-1}$ та зниженими показниками ємності анаеробного енергозабезпечення 13,32 ± 1,52 ммоль·л$^{-1}$. Спортсмени виконали достатній обсяг роботи в степ-тесті (3-4 кроки), але показники в тесті 90 с знизилися, знизилися характеристики здатності компенсувати втому.

Третя типологічна група (La max 90 с – > 16,64 ммоль·л$^{-1}$, $p < 0,05$) характеризується: показниками потужності 8,20 ± 2,36 ммоль·л$^{-1}$ та ємністю анаеробного енергозабезпечення 17,85 ± 1,05 ммоль·л$^{-1}$, які були найвищими серед інших груп спортсменів, та достовірно більш високими показниками потужності роботи у 30 с , 90 с тестах, та рівнем потужності роботи, при якому досягнуто максимальне споживання кисню у степ-тесті ($p < 0,05$).

Висновок. Результати досліджень свідчать про відмінності в рівні функціонального забезпечення спеціальної витривалості у веслярів однорідних груп каноеістів, які спеціалізуються на дистанції 1000 м.

Ключові слова: веслування на каное, аеробне енергозабезпечення, анаеробне енергопостачання, спеціальна продуктивність.

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ORIGINAL SCIENTIFIC ARTICLE

ENHANCING STRENGTH, LEG MUSCLE EXPLOSIVE POWER, AND MUSCLE HYPERTROPHY USING HURDLE-BOX JUMP PLYOMETRIC

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Abstract

The study purpose was to examine and analyze the effect of developing a hurdle-box jump plyometric model on muscle strength, explosive power, and hypertrophy.

Materials and methods. This research was an experimental study with a two group pretest-posttest design. The sample in this study was male sub-elite athletes from various sports aged 15-17 years who were selected at random sampling totaling 22 athletes, divided into 2 (two) groups, the treatment group using plyometric hurdle-box jump development (n = 11) and the control group using plyometric barrier hops (n = 11).

Results. The results showed that: (1) there was a significant effect of plyometric hurdle-box jump exercise on strength, leg muscle explosive power, and muscle hypertrophy, (2) there was a significant effect of plyometric barrier hops exercise (control group) on strength, leg muscles explosive power, and muscle hypertrophy, and (3) there was a significant difference between plyometric hurdle-box jump exercises and plyometric barrier hops exercises (control group) on strength, leg muscle explosive power, and muscle hypertrophy.

Conclusions. The percentage increase in pretest and posttest scores on strength, leg muscle explosive power, and muscle hypertrophy showed that the hurdle-box jump plyometric exercise group was better than the control group (barrier hops).

Keywords: plyometric exercise, strength, leg muscle explosive power, muscle hypertrophy, lower extremity.

Introduction

To achieve maximum performance in achievement sports, very long coaching is needed (Bompa & Buzzichelli, 2019). Trainers, sportsmen, nutritionists, and several other experts such as experts in physical conditions and physiology also play an important role in this achievement (Barnamehei et al., 2020). Coaching starts from the multilateral stage with the introduction of various sports to the specialization stage of one particular branch that is really involved and prospective for maximum achievement (Clemente et al., 2016). The role of the trainer is very large in the process, including preparing the motor skills (physical), technique, tactics, and mentality of athletes (Clark et al., 2018).

Physical elements, especially leg power, are needed in achievement sports to support and support performance when practicing or competing (Asadi, 2016). Efforts to prepare these abilities have been prepared by trainers with various forms of exercise applied (DeWeese et al., 2015). The methods used vary widely, both using inner loading and outer loading (Nygaard Falch et al., 2019). However, until now the effective form of exercise to increase leg muscle power is still being debated (Bompa & Buzzichelli, 2019). Therefore, research on the effect of developing plyometric hurdle-box jump models on increasing strength, leg muscle explosive power, and muscle hypertrophy is necessary.

Plyometric exercises that use inner load have been used as an exercise method, especially to develop strength, speed, and explosive power (Asadi & Ramírez-Campillo, 2016). Strength, speed and power are a series of very important physical components in various sports (Blocquiaux et al., 2020). In the sport of cycling, leg muscle power has a greater contribution, when compared to the elements of balance

and agility (33% leg power, 13% balance, and 26% agility) (Douglas et al., 2021). This shows that leg muscle power is also very necessary in sports, especially sports that require fast movements such as athletics, swimming, tennis (Castillo et al., 2012). Muscle explosive power in both the upper and lower extremities is a dominant physical component and has a major role in improving athlete performance (Branco et al., 2021). Plyometric training principles can be used in various other sports with training loads that are tailored to each sport (Cezar et al., 2013). With plyometric exercises a person can increase strength, muscle explosive power, and hypertrophy through the process of stretching and shortening of muscle fibers (Chaabene et al., 2020).

From the various descriptions above, the form of plyometric training needs to be developed so that it can be used effectively and efficiently in various sports (Donald A. Chu & Gregory D. Myer, 2013). The development of the exercise used in this research is the plyometric hurdle-box jump model, which is jumping forward with a given obstacle or stimulus in the form of a goal and a box, each height of which has been adjusted and adjusted to the anthropometric condition of the athlete (sample) (Aminaei et al., 2017). The basis for giving weights to the plyometric hurdle-box jump exercise refers to studies of the principles and periodization of the exercise (Cuthbert et al., 2021).

The study purpose was to examine and analyze the effect of developing a hurdle-box jump plyometric model on muscle strength, explosive power, and hypertrophy.

Materials and Methods

Study participants

The design in this study used a two-group pretest-posttest design. This method is to tests the effect of one or more variables on other variables. The samples used in this study were athletes from several sports aged 15-17 years with a total sample of 22 athletes who were divided into two treatment and control groups. Samples from PUSLATKOT KONI Kediri City which was prepared for PORPROV East Java VII 2022. The sample was selected from several sports athletes who have at least > 3 (three) years of training, have won/ranked 3 (three) major competitions at the East Java Province level, and have no history of recurrent severe injuries to the lower extremities of the body. The sample was divided into two (2) groups, the treatment group using the development of plyometric hurdle-box jump (n = 11) and control groups using plyometric barrier hops (n = 11) samples and parents have read and filled Informed consent for approval to be sampled research and provide an understanding of the effects of the given exercise.

Study organization

Determination of treatment and control groups was selected based on a simple random sampling technique. The treatment group was given a hurdle-box jump plyometric development exercise with a frequency of 3 times/week for 4 weeks with the number of obstacles (hurdles and boxes) increasing every week. The control group was given plyometric barrier hops treatment with the same loading. This research has received an ethics test certificate from the Unusa Ethics Committee. All tests (instruments) selected were to determine the effect of exercise, performed before and after 4 weeks of exercise intervention. Tests are assessed and administered in one session (morning 07:00-09.00 or afternoon 15.30-17.30). The first test scores are leg muscle strength using a leg dynamometer, then leg muscle explosive power using jump MD, and the last item is measuring muscle hypertrophy using a candy mini meter. Each test item is carried out 2 (two) times to reduce the occurrence of human errors. In the implementation of the test, a 1-2 minute rest period is given in 1 (one) test item and 3-5 minutes between test items to obtain maximum athlete condition so that the test results can be taken optimally. All samples/athletes are encouraged and asked not to do strenuous activities within 1x24 hours before the test is carried out both on the initial ability test (pretest) and the final ability test (posttest), in addition, samples/athletes are advised not to consume heavy food < 2 hours before carrying out the test. This test is conducted on a gravel track, and the test takers wear training/sports equipment. Before the test, participants warmed up both dynamically and statically for ± 30 minutes to avoid injury to the organs involved.

Statistical analysis

To test the normality of the data used Kolmogorov Smirnov. The test criteria, if the statistical significance of the calculated price is greater than = 0.05 (5%), the data distribution is normal. To calculate the data homogeneity test, the Levene Test formula is used. The test criteria, if the statistical significance of the calculated price is greater than = 0.05 (5%), the variance of the data is homogeneous. The data analysis technique used is the F-test using the SPSS program.

Results

Descriptive Statistics

The statistical descriptive of the plyometric hurdle-box jump exercise development group is presented in Table 1.

Table 1. Descriptive Statistics of the Hurdle-Box Jump Group

Statistics	Strength		Explosion power		Hypertrophy	
	Pre	Post	Pre	Post	Pre	Post
N	11	11	11	11	11	11
mean	220.0	278.56	52.50	57.25	48.21	50.66
elementary school	46.22	27.732	6.240	5.754	3.324	3.591
Min	156.0	217.00	45.00	51.00	45.30	47.61
Max	291.0	301.00	68.00	70.00	56.75	61.25
Sum	3536.0	4473.0	856.0	932.0	787.3	826.55

Based on table 1, there is an increase in the average level of strength, explosive power, and muscle hypertrophy. Average strength from 220 kg to 278.56 kg. The average leg muscle explosive power from 52.50 cm to 57.25 cm. The mean muscle hypertrophy from 48.21 cm to 50.66 cm.

Table 2. Descriptive Statistics of the Control Group (Barrier Hops)

Statistics	Strength		Explosion power		Hypertrophy	
	Pre	Post	Pre	Post	Pre	Post
N	11	11	11	11	11	11
mean	224.25	253.37	52.25	54.68	49.79	50.59
elementary school	48.452	38.964	4.534	4.551	3.695	3.582
Min	156.0	179.00	41.00	42.00	41.30	41.85
Max	296.0	301.00	62.00	64.00	54.12	54.92
Sum	3614.0	4080,0	853.0	892.0	795.35	807.95

Based on table 2, there is an increase in the average level of strength, explosive power, and muscle hypertrophy. Average strength from 224.25 kg to 253.37 kg. The average leg muscle explosive power from 52.25 cm to 54.68 cm. The mean muscle hypertrophy from 49.79 cm to 50.59 cm. After descriptive analysis, normality and homogeneity tests were carried out using the Kolmogorov Smirnov test and Levene test.

Normality Test Results

Table 3. Normality Test

Group	p	Sig.	Information
Hurdle-Box Jump Group			
Strength Pretest	0.635	0.05	Normal
Strength Posttest	0.362	0.05	Normal
Explosive Power Pretest	0.833	0.05	Normal
Explosive Power Posttest	0.942	0.05	Normal
Pretest Hypertrophy	0.681	0.05	Normal
Posttest Hypertrophy	0.883	0.05	Normal
Control Group (Barrier Hops)			
Strength Pretest	0.562	0.05	Normal
Strength Posttest	0.744	0.05	Normal
Explosive Power Pretest	0.906	0.05	Normal
Explosive Power Posttest	0.761	0.05	Normal
Pretest Hypertrophy	0.765	0.05	Normal
Posttest Hypertrophy	0.852	0.05	Normal

Based on table 3, it can be seen that all data have a p value (Sig.) > 0.05, meaning that the variables are normally distributed.

Homogeneity Test Results

The results of the homogeneity test of this study can be seen in Table 4.

Table 4. Homogeneity Test

Group	df1	df2	sig,	Information
Group Hurlde-Box Jump				
Pre-post Strength	1	11	0.112	Homogeneous
Pre-post Explosive Power	1	11	0.756	Homogeneous
Pre-post Hypertrophy	1	11	0.756	Homogeneous
Control Group (Barrier Hops)				
Pre-post Strength	1	11	0.137	Homogeneous
Pre-post Explosive Power	1	11	0.846	Homogeneous
Pre-post Hypertrophy	1	11	0.879	Homogeneous

From Table 4, it can be seen that the pretest-posttest values of sig. p > 0.05, it means that the data is homogeneous.

Based on the results of the F-test in Table 5 above, it can be seen that the calculated F and the F table (df 15) are 4.543 with a p significance value of 0.000. Because F count > F table 4.543, and a significance value of 0.000 < 0.05, this result shows that there is a significant difference. Thus, the hypothesis which states that there is a significant effect of plyometric hurdle-box jump exercise on strength, leg muscle explosive power, and hypertrophy, has been proven.

Table 5. Test-F Results pretest and posttest Group Exercise Plyometic-Box Jump Hurdle

Variable	mean	F_{ht}	F_{tb}	sig,	Difference	%
Strength	220.00 278.56	18.880	4.543	0.000	58.5625	26.49
Explosive power	52.50 57.25	5.009	4.543	0.033	4.75	8.89
Hypertrophy	48.21 50.66	6.510	4.543	0.028	2.45	4.97

Based on the results of the t-test in Table 6, it can be seen that the calculated F and the F table (df 15) are 4.543 with a p significance value of 0.000. Because F count > Ftable 4.543, and a significance value of 0.000 < 0.05, these results indicate that there is a significant difference. Thus the hypothesis which states that there is a significant effect of plyometric barrier hops training on strength, leg muscle explosive power, and hypertrophy, has been proven.

Table 6. Test-F Results pretest and posttest control group (Barrier Hops)

Variable	mean	F_{ht}	F_{tb}	sig,	Difference	%
Strength	224.25 253.37	14.600	4.543	0.042	29.125	12.93
Explosion power	52.25 54.68	5.64	4.543	0.000	2.4327	4.57
Hypertrophy	49.79 50.59	4.754	4.543	0.000	0.79	1.58

Based on the results of the analysis, the data obtained in Table 7. Based on the results of the F-test in Table 7, it can be seen that the calculated F and the F table (df 15) are 4.543

Table 7. F-Test Results of Hurdle-Box Jump Group and Barrier Hops Group (Control)

Variable	mean	F_{ht}	F_{tb}	sig,	Difference	%
Strength	58.5625	4.730	4.543	0.038	29.437	26.49
	29.1250					12.93
Explosion power	4.7500	6.202	4.543	0.019	2.312	8.89
	2.4375					4.57
Hypertrophy	2.45	78.659	4.543	0.00	1.66	4.97
	0.79					

with a p significance value of 0.000. Because $F_{count} > F_{table}$ 4.543, and a significance value of 0.000 < 0.05, these results indicate that there is a significant difference between plyometric hurdle-box jump exercises and plyometric barrier hops (control) exercises on strength, leg muscle explosive power, and hypertrophy. These results showed that the average data on strength, leg muscle explosive power, and hypertrophy of the hurdle-box jump plyometric exercise group were better than the plyometric barrier hops exercise group (control).

Discussion

Based on the results of the research that has been carried out, it shows that there is a difference between the mean pretest and posttest, so it can be said that the leg muscle strength of the test-takers has increased significantly, as indicated by the difference in the mean from 221.00 to 279.56. The increase in the results in this study can be seen if the difference between the pretest and posttest means is calculated, namely 58.5625. So it can be concluded that the plyometric hurdle-box jump exercise can increase leg muscle strength by 26.49%. The explosive power of the leg muscles of the test participants experienced a significant increase as indicated by the average difference from 53.5000 to 58.2500. The increase in the results in this study can be seen if the difference between the pretest and posttest means is calculated, which is 4.75. So it can be concluded that the plyometric hurdle-box jump exercise can increase the explosive power of the leg muscles by 8.89%.

Strength is the ability of a muscle or a group of muscles to contract either isotonic, isometric, eccentric and isokinetic with the aim of generating tension against resistance in one work (Egan-Shuttler et al., 2017). Along with physiological adaptation, plyometric training also causes adaptation to several physical elements (Bayindir & Kolayiş, 2015). Plyometric exercises in addition to building strength can also improve the ability of elements of other physical conditions (Angulo et al., 2020). The increase in muscle workability due to weight training is caused by physiological changes that occur in the neuromuscular system (neuromuscular adaptation system) (Farias-Junior et al., 2019).

An increase in muscle size causes stronger muscle contractions (increased explosive power), faster repetition of contractions (increased speed), longer-lasting exercise periods (increases muscle endurance) (Fink et al., 2016). Plyometric exercises are prescribed for both athletes and non-athletes to develop lower body strength (Feriche et al., 2017). Plyometric exercises in addition to increasing strength, there is another goal, namely increasing the size of muscle fibers called hypertrophy (Bostani & Shariati, 2012). Periodization of training determines the target and the number of types of exercise. These results are in line with research conducted by (Clark et al., 2018) that plyometric exercises using pre-arranged or designed loading given to 40 men within 6 weeks with 2 sessions per week showed a significant increase in muscle strength legs.

The muscle hypertrophy of the test participants experienced a significant increase as indicated by the average difference from 49.21 to 51.66. The increase in the results in this study can be seen if the difference between the pretest and posttest means is calculated, which is 2.45. So it can be concluded that plyometric hurdle-box jump exercise can increase muscle fiber size (hypertrophy) by 4.97%.

Muscle hypertrophy is the result of an increase in the number of actin and myosin filaments in each muscle fiber. Strength targets in the preparatory period where training is aimed at increasing large muscle groups such as the legs (Eckardt, 2016). Furthermore, in the preparation period for the second stage of strength training, the goal of strength training is a maximum strength which is continued with power (Fink et al., 2016). Periodization has an effect on increasing muscle strength and hypertrophy (Fischetti et al., 2018). Plyometric exercises can be performed using outer loading such as a vest or weight jacket and a variety of obstacles according to the training objectives and muscle exposure (Gillen et al., 2020). Local muscle damage induced by weight training has also been implicated in mediating muscle growth (Grgic, Schoenfeld, & Mikulic, 2021). Eccentric exercise produces greater gains in lean muscle than concentric and isometric contractions (Vassil & Bazanovk, 2012). This will trigger maximal muscle hypertrophy in response to resistance training is not achieved unless eccentric muscle action is performed (Gordon et al., 2012). Exercise programs that use outer loading will accelerate the process of hypertrophy in muscles (Grgic, Schoenfeld, & Mikulic, 2021). From the results of the analysis, it can be concluded that the plyometric hurdle-box jump exercise is effective for increasing strength, power, and muscle hypertrophy, especially in the lower extremities.

The results showed that there was an effect of plyometric barrier hops training on strength, explosive power, and muscle hypertrophy. It can be seen from each variable that there is a difference between the mean pretest and posttest, so it can be said that the leg muscle strength of the test-takers has increased significantly as indicated by the difference in the mean of 225.25 to 254.38. The increase in the results in this study can be seen if the difference between the pretest and posttest means is calculated, which is 29.125. So it can be concluded that the plyometric barrier hops exercise can increase leg muscle strength by 12.93%. The explosive power of the leg muscles of the test participants experienced a significant increase as indicated by the average difference from 53.2500 to 55.6875. The increase in the results in this study can be seen if the difference between the pretest and posttest means is calculated, which is 2.4327. So it can be concluded that the plyometric barrier hops exercise can increase leg muscle strength by 4.57%. Plyometric barrier hops is one of several plyometric training models by provide obstacles consisting of small hurdles arranged and arranged at a predetermined distance, and easier to implement because the

goal used is not too high and suitable to be given to children or children. non-athletes (Fischetti et al., 2018).

The muscle hypertrophy of the test participants experienced a significant increase as indicated by the average difference from 49.77 to 50.56. The increase in the results in this study can be seen when the difference between the pretest and posttest means is calculated, which is 0.79. So it can be concluded that plyometric barrier hops exercise can increase muscle fiber size (hypertrophy) by 1.58%. The training period determines the target and the number of types of exercise (Bompa & Buzzichelli, 2019). Strength targets in the training preparatory period are aimed at increasing large muscle groups such as the legs (Blocquiaux et al., 2020). Furthermore, in the preparation period for the second stage of strength training, the goal of strength training is a maximum strength which is continued with power (Gillen et al., 2020). Furthermore, (Gordon et al., 2012) stated that periodization has an effect on increasing muscle strength and hypertrophy. Pressure on muscle contraction is the most dominant mediator of muscle hypertrophy (Grgic, Schoenfeld, Orazem, et al., 2021). From the results of the analysis, it can be concluded that the plyometric barrier hops exercise is effective for increasing strength, leg muscle explosive power, and muscle hypertrophy.

The results showed that there were differences in the effect of plyometric hurdle-box jump and barrier hops exercises on strength, muscle explosive power, and hypertrophy. Judging from the results of the percentage increase in scores between pretest and posttest, it was shown that the percentage increase in the plyometric hurdle-box jump exercise group was higher than the plyometric barrier hops exercise on strength, explosive power, and hypertrophy. The hurdle-box jump plyometric exercise is better than the barrier hops plyometric exercise on strength, leg muscle explosive power, and hypertrophy.

Exercise plyometric hurdle-box jump is an exercise with jumping movement towards vertical-horizontal with the provision of obstacles wicket as high as 80% of the long legs of athletes and boxes as high as 80% long-calf (gastrocnemius) carried by the rhythm/contraction very rapidly in order to develop and improve strength and leg muscle explosive power in athletes (not recommended for non-athletes). On the other hand, plyometric barrier hops exercise as an exercise by jumping in a vertical direction by providing a small hurdle as high as 30-45 cm which is carried out with a rhythm or rapid contraction with the aim of developing and increasing the strength and explosive power of the user's leg muscles (can be given to athletes). and non-athletes) (Haugen et al., 2019). The plyometric hurdle-box jump and barrier hop exercises have the following characteristics: (a) they both provide an increase in physical biomotor aspects, (b) they allow rapid muscle contraction movements, (c) both require good jumping ability and (d) both allow progressive resistance. These four traits are critical to the benefits an effective plyometric training program offers. Despite the similarities between the hurdle-box jump and the barrier hop, one would assume that the hurdle-box jump is better. Plyometric hurdle-box jump has the following advantages: (a) it is used for exercises that increase most of the body's muscles, (b) it has a high level of safety so it does not injure or injure the wearer, (c) it can be easily moved to suit conditions. the training ground, (d) involve a range of motion and muscle activation similar to that in many sports movements especially for the lower body, and (e) minimize costs (low cost).

Furthermore, this study is supported by (Hayward et al., 2013) that plyometric exercises using the hurdle jump and box jump models are more effective or have a greater effect than plyometric exercises using the barrier hops model. This is also evidenced by (Jakobsen et al., 2013) in his research comparing plyometric hurdle jump and box jump models given to 60 male athletes within 4 weeks with 3 sessions per week showing a significant increase in leg muscle strength. Of the two types of exercise plyometric models of hurdle jumps and box, jumps are superior to the exercise plyometric model of barrier hops.

The effect of plyometric hurdle-box jumps and barrier hops in the study seen from the loading factor showed that there was a significant increase in muscle fiber growth (muscle hypertrophy), in loading the important factor was to provide sufficient load on the muscles that were stimulated to grow (Hammami et al., 2020). The results showed that the plyometric hurdle-box jump exercise effect was more effective than the barrier hops plyometric exercise results. This can be seen from the loading characteristics of the two methods, the plyometric hurdle-box jump exercise involves strong and fast muscle contractions that require a person to use more muscles (Kruse et al., 2015). It can be concluded that the hurdle-box jump plyometric exercise is higher in benefit and effectiveness than the barrier hops plyometric exercise on strength, leg muscle explosive power, and hypertrophy.

Conclusion

Based on the results of the research and the results of data analysis that has been carried out, the following conclusions are obtained: (1) there is an effect of plyometric hurdle-box jump exercise on strength, leg muscle explosive power, and muscle hypertrophy, (2) there is an effect of plyometric barrier hops exercise on strength, leg muscle explosive power, and muscle hypertrophy, (3) there are differences in the effect of plyometric hurdle-box jump exercises and plyometric barrier hops exercises on strength, leg muscle explosive power, and muscle hypertrophy. Based on the percentage increase in pretest and posttest scores on strength, leg muscle explosive power, and muscle hypertrophy, the hurdle-box jump plyometric exercise group was better than the barrier hops plyometric exercise group.

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Conflict of Interest

The authors declare that there is no conflict of interest.

References

Bompa, T. O., & Buzzichelli, C. A. (2019). Peridization: Theory and Methodology of Training. *Journal of Chemical Information and Modeling, 6*(6).

Barnamehei, H., Tabatabai Ghomsheh, F., Safar Cherati, A., & Pouladian, M. (2020). Muscle and joint force dependence of scaling and skill level of athletes in high-speed overhead task: Musculoskeletal simulation study. *Informatics in Medicine Unlocked,* 20, 100415. https://doi.org/10.1016/j.imu.2020.100415

Clemente, F. M., Nikolaidis, P. T., Martins, F. M. L., & Mendes, R. S. (2016). Weekly physical activity patterns of university students: Are athletes more active than non-athletes? *SpringerPlus, 5*(1), 3-9. https://doi.org/10.1186/s40064-016-3508-3

Clark, D. R., Lambert, M. I., & Hunter, A. M. (2018). Contemporary perspectives of core stability training for dynamic athletic performance: a survey of athletes, coaches, sports science and sports medicine practitioners. *Sports Medicine – Open, 4*(1). https://doi.org/10.1186/s40798-018-0150-3

Asadi, A. (2016). Plyometric type neuromuscular exercise is a treatment to postural control deficits of volleyball players: A case study. *Revista Andaluza de Medicina Del Deporte, 9*(2), 75-79. https://doi.org/10.1016/j.ramd.2016.02.004

DeWeese, B. H., Hornsby, G., Stone, M., & Stone, M. H. (2015). The training process: Planning for strength-power training in track and field. Part 2: Practical and applied aspects. *Journal of Sport and Health Science, 4*(4), 318-324. https://doi.org/10.1016/j.jshs.2015.07.002

Nygaard Falch, H., Guldteig Rædergård, H., & van den Tillaar, R. (2019). Effect of Different Physical Training Forms on Change of Direction Ability: a Systematic Review and Meta-analysis. *Sports Medicine – Open, 5*(1). https://doi.org/10.1186/s40798-019-0223-y

Asadi, A., & Ramírez-Campillo, R. (2016). Effects of cluster vs. traditional plyometric training sets on maximal-intensity exercise performance. *Medicina (Lithuania), 52*(1), 41-45. https://doi.org/10.1016/j.medici.2016.01.001

Blocquiaux, S., Gorski, T., Van Roie, E., Ramaekers, M., Van Thienen, R., Nielens, H., Delecluse, C., De Bock, K., & Thomis, M. (2020). The effect of resistance training, detraining and retraining on muscle strength and power, myofibre size, satellite cells and myonuclei in older men. *Experimental Gerontology,* 133, 110860. https://doi.org/10.1016/j.exger.2020.110860

Douglas, J., Ross, A., & Martin, J. C. (2021). Maximal muscular power: lessons from sprint cycling. *Sports Medicine – Open, 7*(1). https://doi.org/10.1186/s40798-021-00341-7

Castillo, F., Valverde, T., Morales, A., Pérez-Guerra, A., de León, F., & García-Manso, J. M. (2012). Potencia máxima, potencia óptima y espectro óptimo en el entrenamiento de la potencia del miembro superior (bench press): Una revisión. *Revista Andaluza de Medicina Del Deporte, 5*(1), 18-27. https://doi.org/10.1016/S1888-7546(12)70005-9

Branco, B. H. M., Andreato, L. V., Ribeiro, E. D., de Oliveira, H. G., Almeida, F. N., & Junior, N. N. (2021). Correction to: Development of tables for classifying judo athletes according to maximal isometric strength and muscular power, and comparisons between athletes at different competitive levels. *Sport Sciences for Health, 17*(1), 265-266. https://doi.org/10.1007/s11332-020-00720-9

Cezar, H., Doina, C., Dan, B., & Gheorghe, G. (2013). Study Concerning the Developing of the Explosive Strength in Sport Games. *Procedia - Social and Behavioral Sciences,* 93, 1922-1925. https://doi.org/10.1016/j.sbspro.2013.10.141

Chaabene, H., Lesinski, M., Behm, D. G., & Granacher, U. (2020). Performance - and health-related benefits of youth resistance training. *Sports Orthopaedics and Traumatology, 36*(3), 231-240. https://doi.org/10.1016/j.orthtr.2020.05.001

Donald A. Chu, P., & Gregory D. Myer, P. (2013). *Plyometrics.* Human Kinetics.

Aminaei, M., Yazdani, S., & Amirseifadini, M. (2017). Effects of Plyometric and Cluster Resistance Training on Explosive Power and Maximum Strength in Karate Players. *International Journal of Applied Exercise Physiology, 6*(2), 34-44. https://doi.org/10.22631/ijaep.v6i2.142

Cuthbert, M., Haff, G. G., Arent, S. M., Ripley, N., McMahon, J. J., Evans, M., & Comfort, P. (2021). Effects of Variations in Resistance Training Frequency on Strength Development in Well-Trained Populations and Implications for In-Season Athlete Training: A Systematic Review and Meta-analysis. *Sports Medicine, 51*(9), 1967-1982. https://doi.org/10.1007/s40279-021-01460-7

Egan-Shuttler, J. D., Edmonds, R., Eddy, C., O'Neill, V., & Ives, S. J. (2017). The Effect of Concurrent Plyometric Training Versus Submaximal Aerobic Cycling on Rowing Economy, Peak Power, and Performance in Male High School Rowers. *Sports Medicine – Open, 3*(1), 1-10. https://doi.org/10.1186/s40798-017-0075-2

Bayindir, B., & Kolayiş, İ. E. (2015). Comparision of Strenght Speed and Endurance in 11-13 Age Boys and Girls. *Procedia – Social and Behavioral Sciences,* 174, 3292-3298. https://doi.org/10.1016/j.sbspro.2015.01.996

Angulo, J., El Assar, M., Álvarez-Bustos, A., & Rodríguez-Mañas, L. (2020). Physical activity and exercise: Strategies to manage frailty. *Redox Biology,* 35, 101513. https://doi.org/10.1016/j.redox.2020.101513

Farias-Junior, L. F., Browne, R. A. V., Freire, Y. A., Oliveira-Dantas, F. F., Lemos, T. M. A. M., Galvão-Coelho, N. L., Hardcastle, S. J., Okano, A. H., Aoki, M. S., & Costa, E. C. (2019). Psychological responses, muscle damage, inflammation, and delayed onset muscle soreness to high-intensity interval and moderate-intensity continuous exercise in overweight men. *Physiology and Behavior,* 199, 200-209. https://doi.org/10.1016/j.physbeh.2018.11.028

Fink, J., Kikuchi, N., Yoshida, S., Terada, K., & Nakazato, K. (2016). Impact of high versus low fixed loads and non-linear training loads on muscle hypertrophy, strength and force development. *SpringerPlus, 5*(1), 1-8. https://doi.org/10.1186/s40064-016-2333-z

Feriche, B., García-Ramos, A., Morales-Artacho, A. J., & Padial, P. (2017). Resistance Training Using Different Hypoxic Training Strategies: a Basis for Hypertrophy and Muscle Power Development. *Sports Medicine – Open, 3*(1). https://doi.org/10.1186/s40798-017-0078-z

Bostani, M., & Shariati, M. (2012). The Comparison of Between the Effects of Two Training Methods on Dynamic Strength of Non-Athletes Males. *Procedia – Social and Behavioral Sciences,* 46, 417-420. https://doi.org/10.1016/j.sbspro.2012.05.133

Eckardt, N. (2016). Lower-extremity resistance training on unstable surfaces improves proxies of muscle strength, power and balance in healthy older adults: a randomised control trial. *BMC Geriatrics, 16*(1), 1-15. https://doi.org/10.1186/s12877-016-0366-3

Fischetti, F., Vilardi, A., Cataldi, S., & Greco, G. (2018). Effects of plyometric training program on speed and explosive strength of lower legs in young athletes. *Journal of Physical Education and Sport, 18*(4), 2476-2482. https://doi.org/10.7752/jpes.2018.04372

Gillen, Z. M., Shoemaker, M. E., McKay, B. D., Bohannon, N. A., Gibson, S. M., & Cramer, J. T. (2020). Leg Extension Strength, Explosive Strength, Muscle Activation, and Growth as Predictors of Vertical Jump Performance in Youth Athletes. *Journal of Science in Sport and Exercise, 2*(4), 336-348. https://doi.org/10.1007/s42978-020-00067-0

Grgic, J., Schoenfeld, B. J., & Mikulic, P. (2021). Effects of plyometric vs. resistance training on skeletal muscle hypertrophy: A review. *Journal of Sport and Health Science, 10*(5), 530-536. https://doi.org/10.1016/j.jshs.2020.06.010

Vassil, K., & Bazanovk, B. (2012). The effect of plyometric training program on young volleyball players in their usual training period. *Journal of Human Sport and Exercise, 7*(1 SPECIAL ISSUE), 11-14. https://doi.org/10.4100/jhse.2012.7.Proc1.05

Gordon, D., Mullane, S. L., Conway, P. P., & West, A. A. (2012). Development of a novel system for monitoring strength and conditioning in elite athletes. *Procedia Engineering,* 34, 496-501. https://doi.org/10.1016/j.proeng.2012.04.085

Grgic, J., Schoenfeld, B. J., Orazem, J., & Sabol, F. (2021). Effects of resistance training performed to repetition failure or non-failure on muscular strength and hypertrophy: A systematic review and meta-analysis. *Journal of Sport and Health Science,* S2095254621000077. https://doi.org/10.1016/j.jshs.2021.01.007

Haugen, T., Seiler, S., Sandbakk, Ø., & Tønnessen, E. (2019). The Training and Development of Elite Sprint Performance: an Integration of Scientific and Best Practice Literature. *Sports Medicine – Open, 5*(1). https://doi.org/10.1186/s40798-019-0221-0

Hayward, S., Urbina, S., Jones, C., Holt, J., Burks, B., Ralph, K., Foster, C., Wells, S., Wildman, R., Smith-Ryan, A., Taylor, L., & Wilborn, C. (2013). Effects of XPAND® on anaerobic power, muscular strength & subjective measures of mood state. *Journal of the International Society of Sports Nutrition, 10*(S1), 9-10. https://doi.org/10.1186/1550-2783-10-s1-p9

Jakobsen, M. D., Sundstrup, E., Andersen, C. H., Aagaard, P., & Andersen, L. L. (2013). Muscle activity during leg strengthening exercise using free weights and elastic resistance: Effects of ballistic vs controlled contractions. *Human Movement Science, 32*(1), 65-78. https://doi.org/10.1016/j.humov.2012.07.002

Hammami, M., Bragazzi, N. L., Hermassi, S., Gaamouri, N., Aouadi, R., Shephard, R. J., & Chelly, M. S. (2020). The effect of a sand surface on physical performance responses of junior male handball players to plyometric training. *BMC Sports Science, Medicine and Rehabilitation, 12*(1), 1-8. https://doi.org/10.1186/s13102-020-00176-x

Kruse, N. T., Barr, M. W., Gilders, R. M., Kushnick, M. R., & Rana, S. R. (2015). Effect of different stretching strategies on the kinetics of vertical jumping in female volleyball athletes. *Journal of Sport and Health Science, 4*(4), 364-370. https://doi.org/10.1016/j.jshs.2014.06.003

ПІДВИЩЕННЯ СИЛИ, ВИБУХОВОЇ СИЛИ М'ЯЗІВ НІГ І ГІПЕРТРОФІЇ М'ЯЗІВ ЗА ДОПОМОГОЮ ПЛІОМЕТРИЧНОГО СТРИБКА З БАР'ЄРОМ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 8 с., 7 табл., 36 джерел.

Мета дослідження полягала в тому, щоб вивчити та проаналізувати вплив розробленої пліометричної моделі стрибка з перешкодами на силу м'язів, вибухову силу та гіпертрофію.

Матеріали та методи. Це дослідження було експериментальним дослідженням із двома групами передтест-посттест. Вибіркою в цьому дослідженні були спортсмени-чоловіки з різних видів спорту віком 15-17 років, які були відібрані шляхом випадкової вибірки загальною кількістю 22 спортсменів, поділених на дві групи, група впливу з використанням пліометричного розвитку стрибків з бар'єрами (n = 11) та контрольна група з використанням пліометричних бар'єрних стрибків (n = 11).

Результати. Результати показали, що: (1) був значний вплив пліометричної вправи зі стрибками з бар'єром на силу, вибухову силу м'язів ніг і гіпертрофію м'язів, (2) був значний вплив пліометричних вправ з бар'єрним стрибком (контрольна група) на силу, вибухову силу м'язів ніг і гіпертрофія м'язів, і (3) була значна різниця між пліометричними вправами зі стрибками з бар'єром і пліометричними вправами з бар'єрним стрибком (контрольна група) щодо сили, вибухової сили м'язів ніг і гіпертрофії м'язів.

Висновки. Відсоткове збільшення показників до і після тесту за силою, вибуховою силою м'язів ніг і гіпертрофією м'язів показало, що група пліометричних вправ зі стрибками з бар'єрами була кращою, ніж контрольна група (перескоки з бар'єром).

Ключові слова: пліометричні вправи, сила, вибухова сила м'язів ніг, гіпертрофія м'язів, нижня кінцівка.

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ORIGINAL SCIENTIFIC ARTICLE

REACTIVE STRESS TOLERANCE IN PREADOLESCENT SPORTS PARTICIPANTS: A COMPARISON OF SIX INDIVIDUAL NON-CONTACT SPORTS

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Abstract

Purpose of the study. The study's aim was to examine how reactive stress tolerance differs in preadolescence across six different non-contact sports.

Materials and Methods. Archery, cycling, shooting, swimming, track & field, and weightlifting are non-contact sports chosen for research. The study included 180 male sports cadets from the Jharkhand State Sports Promotion Society, with an age range of 11–13 years. To assess reactive stress tolerance, the determination test form S1 under the Vienna Test System was used. Sub-variables like the percentile ranks of correct, incorrect, and omitted responses, as well as the score of median reaction time, were selected for study. Comparisons were made between scores of sub-variables under the reactive stress tolerance of six selected sports disciplines. The main effect was determined using the Kruskal-Wallis test, while pairwise post-hoc comparisons were made using the Mann-Whitney U test. The significance level was set at 0.05.

Results. There were no significant differences in percentile rank of correct, incorrect, and median reaction times between selected sports. In terms of percentile rank of incorrect responses, sports like archery, shooting, and weightlifting differ significantly from swimming.

Conclusion. According to the findings, the sports in which distance is covered by producing bodily momentum are less likely to exhibit uncontrollable behaviour during athletic events.

Keywords: reactive stress tolerance, young athletes, archery, cycling, shooting, swimming, track and field, and weightlifting.

Introduction

Actual performance can only be observed in the main competition, but the factors that influence performance may be examined before the event (Chahal, Ghildyal, & Chahal, 2012). One of these factors is the information processing approach, a cognitive psychology component. The primary focus of this approach is the storage and retrieval of information from memory (Huitt, 2003).

When a sportsperson competes, they are well prepared and aware of the body movements and motor skills that they will be executing (Taneja & Zutshi, 2019). Being familiar with the training environment, the situations are known, but during competition, each timeframe brings an unknown stimulus. As a consequence of a change in the athlete's external environment, changes in the athlete's internal environment may occur (Bali, 2015), causing difficulty in performing previously learned skills (Allard & Starkes, 1991). In such situations, the behaviours observed are not under the conscious control of the athlete and can be seen in sensorimotor or action-based skills (Baumeister, 1984; Lewis & Linder, 1997), causing the athlete to perform worse than expected. The phenomenon is known as "choking under pressure" (Masters, 1992; Beilock & Carr, 2001). Pressure may be defined as any factor or combination of factors that increases the importance of performing well on a particular occasion, whereas choking refers to performance decrements under pressure circumstances (Baumeister, 1984). Despite individual effort and situational expectations for higher performance, "choking under pressure" is a figurative idiom used to describe the occurrence of lower performance (Baumeister & Showers, 1986). Choking in sports refers to a drastic drop in athletic performance under stressful circum-

stances (Mesagno & Grant, 2010). In the near term, this has a negative impact on the athlete's performance, and in the long term, it may restrict their degree of sporting success (Hill, Hanton, Matthews, & Fleming, 2010).

In all sports, athletes are trained technically and tactically so that they can make rapid decisions during competition (Nathan, 2017). During training, the circumstances and surroundings are familiar, but in competition the scenario changes, resulting in distraction through external sources that lead to debilitating anxiety and low perceived control, causing a significant drop in performance (Hill, Hanton, Matthews, & Fleming, 2010). In competition, when the conditions (environment and opponent) change, an athlete should be able to recognise the stressor, deal with it, make rapid decisions, and respond correctly to external cues in order to maximise the chances of sporting success (Williams, Hodges, North, & Barton, 2016; Patócs, Melia, Kovács, Fózer-Selmeci, Révész, & Tóth, 2016). If an athlete becomes choked in this situation, he will not be able to respond and will fail to give his best performance. Besides external factors, stress is caused by the quick processing of information in the form of visual, auditory, and audio-visual stimuli, which plays an important role in decision-making (Patócs, Melia, Kovács, Fózer-Selmeci, Révész, & Tóth, 2016). Several studies have found a connection between sports performance and psychology in terms of information processing systems, perceptual skills (Williams, A. M., 2000), multiple-choice reaction and visual perception (Doğan, 2009), competitive and organisational stressors (Hanton, Fletcher, & Coughlan, 2005), psychological skills (Cox, Zhan, & Yijun, 1996), and psychological states in competition (Doron & Martinent, 2015). However, response selection and skill execution play a major part in sporting success that cannot be comprehended only by looking at reaction time. As it is not enough to execute learned skills quickly, the basic tactical skill that an athlete must possess is the selection of the right skill at the right time (Czajkowski, 2009). No doubt, reaction speed matters, but without an appropriate reaction, the reaction speed is of no use (Johne, Poliszczuk, Poliszck, & Dabrowska-Perzyna, 2013).

In the process of making a rapid decision and quickly acting upon it, an individual has a threshold capacity to respond to constantly changing stimuli. This is influenced by individual characteristics, personality types, sports types, etc. (Nathanael, 2017). Sports psychologist states this ability as "reactive stress tolerance." Reactive stress tolerance is defined as an individual's ability to react effectively, quickly, and appropriately to a given circumstance, even in a stressful setting (Schuhfried, 2016).

The study's purpose: The aim of this study was to determine the level of reactive stress tolerance among preadolescent male athletes who actively trained and participated in six different non-contact individual sports (archery, track and field, cycling, shooting, swimming and weightlifting). To accomplish this goal, the sample was chosen from a specific academy that offers a consistent daily schedule and training regimen based on the athlete's developmental age. Female participants were excluded from the study to gain maximum control over extraneous variables like mental health change during adolescence (Fink, Patalay, Sharpe, Holley, Deighton, & Wolpert, 2015; Haugland, Wold, Stevenson, Aaroe, & Woynarowska, 2001; Jones, 2001). A minimum of two years of regularly trained sports cadets were selected for the research in order to ensure training stability.

Materials and Methods

Study participants

Selection of Subjects: A total of 180 male sports participants from the Jharkhand State Sports Promotion Society were selected for the study. 30 participants each from six different non-contact sports (archery, athletics, cycling, shooting, swimming, and weightlifting) were drawn using a stratified random sampling method. The chronological age range of participants was 11–13 years, with a minimum of 2 years of training experience.

Study organization

Variable and Test Selection: The variable chosen for the study was reactive stress tolerance. To measure its parameters, the determination test (DT) form S1 was chosen from the Vienna Test System. Sports were the independent variables, whereas different scores of reactive stress tolerance were kept as dependent variables. The test lasts approximately 6 minutes and includes sound and visual stimuli. The description of the test is presented in Table 1.

Table 1. Illustration of Determination Test

Stimuli Presented	Stimuli	Signal	Reaction	Response Key
Colour	Visual	White	Hand	Round white
		Red		Round red
		Yellow		Round yellow
		Green		Round green
		Blue		Round blue
Foot signal	Audio	Left side	Foot	Left paddle
		Right Side		Right paddle
Tone	Visual	Low 100 Hz	Hand	Rectangle Black
		High 2000 Hz		Rectangle Grey

Selection of Instrument and Scoring: Reactive stress tolerance was administered using a computer-based testing device, the Vienna test system by Schuhfried GmbH. For scoring purposes, the PR (Percentile Rank) of the correct response, the PR of the incorrect response, the PR of the omitted response, and the median reaction time were obtained.

Consent: Because the athletes were minors (under the age of 18), informed consent was obtained from the academy's administration and the athlete's in-charge. Apart from that, each subject was told about the test ahead of time and their agreement was also obtained.

Test Procedure: Test was administered between 9 AM to 5 PM. Selected athletes were well informed in advance about their test date and time. Before the beginning of each test, the computer programme offered a practise set. Once the subject acknowledged the practise set, the real test was conducted. An introspective report (feedback) was gathered at the end, and incentives were handed out.

Statistical Analysis

The Shapiro-Wilk test was employed to ensure the normality of the data. The Kruskal-Wallis test was used to compare measures of reactive stress tolerance in different sports. A pairwise comparison using the Mann-Whitney U test was used as a post-hoc test (Verma, 2016). The level of significance was preserved at p = 0.05. The profile chart was created using mean, standard deviation, minimum and maximum scores. Equation – (1) $z = \frac{X - \bar{X}}{S}$ was used to convert the minimum, maximum, and mean scores to their standard scores, where Z is the standard score, X is the score used for conversion (minimum, maximum, or average), $\bar{x}$ is the mean, and S is the standard deviation. Z values were converted into linear transformed scores using Equation – (2) $Z_1 = 50 + 10 \times Z$, where Z_1 is the linear transformed score of Z, and Z is the interest score for which linear transformation is being done.

Results

The descriptive statistics for the chosen variables are shown in Table 2. In the result, it can be observed that the mean score of weightlifting under the percentile rank of correct response, cycling under the percentile rank of incorrect response, and archery, track & field, swimming, and weightlifting under the median reaction time are nearly equal to their median. The p-values of these variables are only slightly more than 0.05. Therefore, data under PR-C, weightlifting, PR-I, shooting, and MRT, including archery, track and field, swimming, and weightlifting, are considered to be normally distributed.

Figure 1 depicts a descriptive graph of six sports for each variable. On each variable, the scores are found to be broadly distributed.

Although there are 30 samples in each sports category, many variables and sports do not follow a normal distribution. As a result, the nonparametric Kruskal-Wallis Test was employed to compare the scores of reactive stress tolerance of six distinct sports.

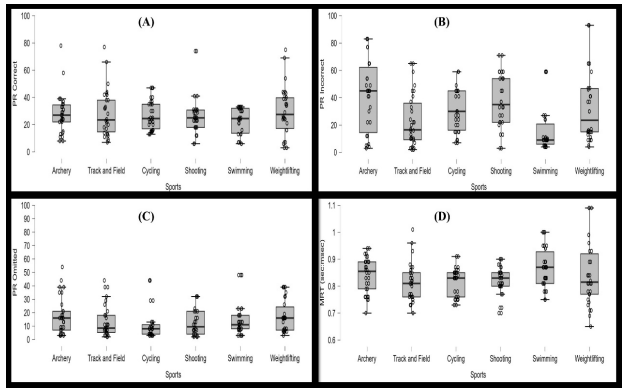

Figure 1. Data Distribution of Sports on Each Variable

Table 3 shows the result of comparative statistics by applying Kruskal-Wallis Test. The values of mean rank, degree of freedom (df), chi-square ($\chi 2$), and p-value were presented. The larger $\chi 2$ value indicates large differences between

Table 2. Descriptive Statistics

Variables	Sports	N	Mean	Median	SD	IQR	Shapiro-Wilk
PR-C	Archery	30	28	27	14.51	14.75	0.003
	Track and Filed	30	28.36	23.5	16.92	25.25	0.019
	Cycling	30	26.9	24.5	10.76	19.50	0.021
	Shooting	30	26.76	25	15.63	13.00	0.000
	Swimming	30	22.56	24.5	9.74	19.00	0.001
	Weightlifting	30	29.56	27.5	18.25	24.75	0.114^
PR-I	Archery	30	40.16	45	25.99	53.00	0.046
	Track and Filed	30	23.1	16.5	19.41	29.50	0.003
	Cycling	30	31.7	30	16.48	30.00	0.047
	Shooting	30	37.66	35	19.64	33.25	0.119^
	Swimming	30	15.86	9	16.26	19.00	0.00
	Weightlifting	30	32.66	23.5	25.17	32.50	0.002
PR-O	Archery	30	17.36	16	13.82	16.00	0.002
	Track and Filed	30	13.73	8.5	12.08	19.75	0.00
	Cycling	30	11.73	8	12.68	7.50	0.00
	Shooting	30	12.53	9.5	9.6	17.25	0.003
	Swimming	30	14.96	11	12.56	10.25	0.00
	Weightlifting	30	17.26	16	12.1	20.75	0.00
MRT	Archery	30	0.84	0.85	0.06	0.11	0.116^
	Track and Filed	30	0.81	0.81	0.07	0.09	0.204^
	Cycling	30	0.81	0.83	0.05	0.09	0.009
	Shooting	30	0.82	0.83	0.06	0.05	0.037
	Swimming	30	0.86	0.87	0.07	0.13	0.106^
	Weightlifting	30	0.84	0.82	0.11	0.17	0.065^

PR-C: Percentile Rank of Correct Response; PR-I: Percentile Rank of Incorrect Response; PR-O: Percentile Rank of Omitted Stimuli; MRT: Median Reaction Time; ^ Non-significant at 0.05

Table 3. Kruskal-Wallis Ranks Test and Variables Test Statistics

Variables	Sports	Mean Rank	df	χ2	p- value
PR-C	Archery	94.25	5	3.218	0.666
	Track and Field	91.63			
	Cycling	92.92			
	Shooting	85.7			
	Swimming	78.22			
	Weightlifting	100.28			
PR-I	Archery	109.42	5	27.478	0.000*
	Track and Field	73.85			
	Cycling	99			
	Shooting	110.93			
	Swimming	54.05			
	Weightlifting	95.75			
PR-O	Archery	101.83	5	8.496	0.131
	Track and Field	84.98			
	Cycling	72.58			
	Shooting	82.82			
	Swimming	96.48			
	Weightlifting	104.3			
MRT	Archery	100.92	5	9.364	0.095
	Track and Field	75.42			
	Cycling	81.77			
	Shooting	85.05			
	Swimming	110.53			
	Weightlifting	89.32			

PR-C: Percentile Rank of Correct Response; PR-I: Percentile Rank of Incorrect Response; PR-O: Percentile Rank of Omitted Stimuli; MRT: Median Reaction Time; * Significant at 0.05

the groups. The percentile rank for incorrect responses has a higher Chi-square value 27.478, and the calculated p-value is < 0.001. It is possible to infer that the percentile rank of incorrect responses varies across six different non-contact sports. Other factors, such as percentile rank of correct response (χ2 = 3.218, p-value = 0.666), percentile rank of omitted stimuli (χ2 = 8.496, p-value = 0.131), and median reaction time (χ2 = 9364, p-value = 0.095) do not show any significant differences. As a result, the percentile rank of correct responses, percentile rank of omitted stimuli, and median reaction time in chosen non-contact sports did not differ significantly.

Figure 2 represents the post-hoc analysis of incorrect responses and demonstrates the mean ranks and p-values of each selected sport. The Mann-Whitney U test was used for the post-hoc analysis. Only four pairs, swimming – cycling (p = 0.012), swimming – archery (p = 0.001), swimming – shooting (p < 0.001), and swimming – weightlifting (p = 0.029), displayed a significant difference.

Following Equation – (1) and (2), a profile chart (Figure 3) was created to compare selected variables of reactive stress tolerance. The minimum and maximum scores demonstrate the upper and lower limits of variables for each sport.

Discussion

The individual sports selected for the study had non-contact characteristics. According to a previous study (Piepiora,

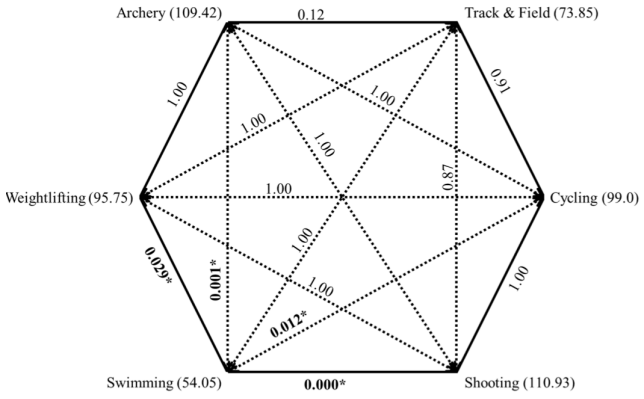

Figure 2. Post-Hoc Comparison of Percentile Ranks of Incorrect Response with (Mean Ranks) and p-values

2021; Pahan & Singh 2021), it was assumed that each parameter of reactive stress tolerance, such as the percentile rank of correct responses, the percentile rank of incorrect responses, the percentile rank of omitted stimuli, and the median reaction time for each sport, would be significantly different.

According to the findings, although there were disparities in scores under the percentile rank of correct response,

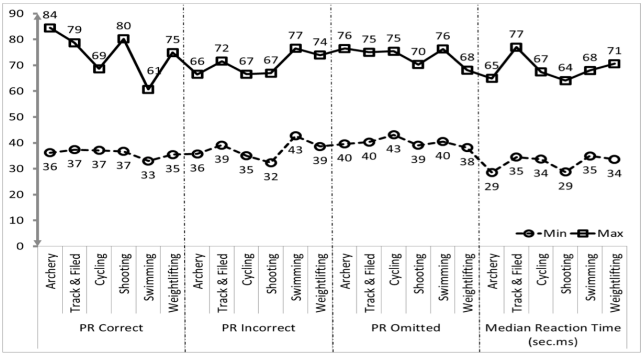

Figure 3. Profile Chart of Reactive Stress Tolerance under Different Individual Non-Contact Sports

percentile rank of omitted stimuli, and median reaction time existed, they did not approach the necessary value to be considered significant. As a result, no significant variation in these characteristics was observed. By examining the visual output of scores in Figure 1 & Table 2, it is clear that there was a wide spread of scores. This indicates that the sample used in the research was more diverse. According to the protocol for avoiding premature specialisation in sports (Committee on Sports Medicine and Fitness, 2000; Launay, 2015; Travassos, Araujo, & Davids, 2017; Buckley et al., 2017), the subject participated in a specific sport but received training appropriate to their age category (chronological, developmental, and training). The trainees were in the preliminary phase of their long-term athletic development. Their training focused more on general physical training than specific sports training. It is possible that this is why the scores under the parameters of reactive stress tolerance displayed a large variation.

According to the developmental aspect of an individual, the age range of 10-14 is categorised as an adolescence period. It is a period of transition from childhood to adulthood

(IGNOU, 2010; Allen & Waterman, 2019). During this stage, there is a rapid change in the way an adolescent perceives their environment. The changes are sudden and various biological, cognitive, and perceptual developments occur. There are some children who reach maturity early and late, while others follow their normal developmental pattern (Thompson, 2009). Individual developmental patterns may be a factor in why homogeneity in the scores was not established.

However, the percentile rank of incorrect responses was found to be statistically significant. The result of a pairwise (post-hoc) comparison revealed that mean ranks of shooting, archery, and weightlifting were statistically higher than swimming. As a result, the commitment to uncontrolled behaviour is higher in shooting, archery, and weightlifting than in swimming. The differences found may be due to the physical nature and requirement of attentional demands in each sport (Laborde, Guillén, & Mosley, 2016). The following are the justifications for acknowledging that the commitment of mistakes varies depending on the physical character of individual non-contact sports.

Nature 1: Equipment Handling vs. Free Hand: Sports like archery and shooting are target-oriented games that require good control of their sport-related equipment (bow, rifle, and pistol). Similarly, weightlifting also demands good control over the barbell and its resistance. Swimming, on the other hand, is a free-hand sport. On this premise, it is reasonable to infer that sports in which equipment is handled are more liable to commit uncontrolled movement. However, this statement is unsatisfactory since the throwing events of track and field and cycling are also sports that need good equipment control.

Nature 2: Speed Dominating vs. Static Stance: For this, it can be said that cycling, swimming, and track and field are the sports which are more speed-dominating. In throwing events of track and field, the distance is achieved by creating momentum, whereas in races, including swimming, track or cycling, momentum is required. If weightlifting is concerned, then it also requires momentum to lift the weight, and on the basis of the generation of momentum, again, it cannot be said that a difference occurred.

Nature 3: Displacement of Own Body vs. Displacement of Equipment: If we understand these individual games, then the factor that is creating the difference can be identified. The factor can be said to be displacement of the body and displacement of equipment. To achieve a desired performance in sports like throwing, jumping, or timing a race (running, swimming, and cycling), momentum is created by covering a fixed distance. Whereas, in weightlifting, archery, and shooting, the athlete does not show any displacement while performing. They have a fixed platform (weightlifting) or a shooting line (target sports) where a participant has to maintain their stance and perform. The athletes of circle throwing events (discus, hammer, and shot-put) in track and field also have a fixed diameter circle. But here they are again creating momentum by displacing their position, which is not similar to weightlifting. Therefore, it can be said that sports where momentum is created by displacing the body have fewer errors in committing behaviour.

From Table 3 and Figure 2, it can be well understood by observing the mean ranks in chronological order that in sports where less physical movement is done, there is a greater chance to choke. In shooting, the preparation of equipment at the time of competition requires less physical input, and gaining stability while shooting shows the higher mean rank. Next is archery, in which an archer has to prepare the equipment by pulling the string and extending the bow hand after placing the arrow. It requires more physical effort as compared to shooting, and hence the mean rank is nearly same but lower than shooting. Similarly, in weightlifting, the foot is placed and fixed during stance, and movement of other body parts is done to lift a weight that requires maximum strength and has a lower mean rank than in archery. Cycling, on the other hand, has a lower mean rank than weight lifting. The nature of sport is handling a cycle where movement is only done by the lower limbs while maintaining the stability of the upper body and controlling the cycle on a line. Track & Field has a lower mean score than cycling, where the jumping, running, and throwing are done, which requires controlled movement of the whole body to achieve performance. In this study, the track and field athletes were not separated and were kept under one category only. Therefore, much information cannot be stated. The swimming at the end scores very little in mean rank. In swimming, a swimmer should have the ability to float on the surface of water while making movements from both the upper and lower body parts. From this, we can understand that in sports where there is less physical demand, the occurrence of unwanted behaviour is greater. Hence, it is not a proven fact and needs further study.

Conclusion

On the basis of the current study, it can be inferred that the level of reactive stress tolerance of six individual non-contact sports only differs by the execution of uncontrolled behaviour. As there are high cognitive demands in each sport, the risk of errors or choking under pressure is greater in sports where the displacement of an athlete's position is very small. Therefore, coaches or physical educationalists who train sportsperson in shooting, archery, and weightlifting should include several kinds of cognitive training to improve the executive function of their trannies. In future research to acquire a better understanding, samples from senior or elite-level athletes may be chosen and categorised according to their personality types and training stages.

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Conflict of Interest

The author declares that there is no conflict of interest

References

Chahal, A., Ghildyal, S., & Chahal, V. (2012). Predicting excellence in basketball: anthropometric and physiological attributes in elite Indian female players. *International quarterly of sport science,* 1, 1-9.

Huitt, W. G. (2003). *The Information Processing Approach to Cognition.* Retrieved December 14, 2021, from Educational psychology interactive: https://vulms.vu.edu.

pk/Courses/PSY504/Downloads/The%20Information%20Processing%20Approach%20to%20Cognition%20article.pdf

Taneja, K., & Zutshi, K. (2019). Effect of Mental Imagery Coupled with Plyometric on Vertical Jump and Agility. *Journal of Advanced Research in Psychology & Psychotherapy, 2*(1), 3-11. https://doi.org/10.24321/2581.5822.201902

Bali, A. (2015). Psychological Factors Affecting Sports Performance. *International Journal of Physical Education, Sports and Health, 1*(6), 92-95. https://www.kheljournal.com/archives/2015/vol1issue6/PartB/1-5-77.pdf

Allard, F., & Starkes, J. L. (1991). *Motor-skill experts in sports, dance, and other domains.* In K. A. Smith, Toward a general theory of expertise: Prospects and limits (pp. 126-152). Cambridge, England: Cambridge University Press.

Baumeister, R. F. (1984). Choking under pressure: self-consciousness and paradoxical effects of incentives on skillful performance. *Journal of Personality and Social Psychology, 46*(3), 610-620. https://doi.org/10.1037//0022-3514.46.3.610

Lewis, B. P., & Linder, D. E. (1997). Thinking about Choking? Attentional Processes and Paradoxical Performance. *Personality and Social Psychology Bulletin, 23*(9), 937-944. https://doi.org/10.1177/0146167297239003

Masters, R. S. (1992). Knowledge, knerves and know how: the role of explicit versus inlplicit knowledge in the breakdown of a complex motor skill under pressure. *British Journal of Psychology,* 83, 343-358. https://doi.org/10.1111/j.2044-8295.1992.tb02446.x

Beilock, S., & Carr, T. (2001). On the fragility of skilled performance: what governs choking under pressure? *Journal of Experimental Psychology: General, 130*(4), 701-725. http://dx.doi.org/10.1037/0096-3445.130.4.701

Baumeister, R. J., & Showers, C. J. (1986). A review of paradoxical performance effects: Choking under pressure in sports and mental test. *European Journal of Social Psychology, 16*(4), 361-383. https://psycnet.apa.org/doi/10.1002/ejsp.2420160405

Mesagno, C., & Grant, T. M. (2010). A Comparison of Different Pre-Performance Routines as Possible Choking Interventions. *Journal of Applied Sport Psychology, 22*(3), 343-360. https://doi.org/10.1080/10413200.2010.491780

Hill, D. M., Hanton, S., Matthews, N., & Fleming, S. (2010). A qualitative exploration of choking in elite golf. *Journal of Clinical Sport Psychology, 4*(3), 221-240. https://doi.org/10.1123/jcsp.4.3.221

Nathan, S. (2017). The Effect of Teaching Games of Understanding as a Coaching Instruction had on Adjust, Cover and Heart Rate among Malaysian and Indian *Junior Hockey Players. Sports, 5*(2), 44. https://doi.org/10.3390/sports5020044

Williams, M. A., Hodges, J. N., North, J. S., & Barton, G. (2016). A study of reaction time and attention control among athletes of sports training centers of Sports Authority of India. *International Journal of Sports Science, 6*(2), 317-332.

Patócs, Á., Melia, L., Kovács, S., Fózer-Selmeci, B., Révész, L., & Tóth, L. (2016). Reactive Stress Tolerance and Personality Characterstics of Hungarian Elite Fencers. Cognition, Brain, Behavior. *An Interdisciplinary Journal, 10*(3), 171-184

Williams, A. M. (2000). Perceptual skill in soccer: Implications for talent identification and development. *Journal of Sports Sciences, 18*(9), 737-750. https://doi.org/10.1080/02640410050120113

Doğan, B. (2009). Multiple-choice reaction and visual perception in female and male elite athletes. J*ournal of Sports Medicine and Physical Fitness, 49*(1), 91-96.

Hanton, S., Fletcher, D., & Coughlan, G. (2005). Stress in elite sport performers: A comparative study of competitive and organizational stressors. *Journal of Sports Sciences, 23*(10), 1129-1141. https://doi.org/10.1080/02640410500131480

Cox, R. H., Zhan, L., & Yijun, Q. (1996). Psychological skills of elite Chinese athletes. *International Journal of Sport Psychology, 27*(2), 123-132.

Doron, J., & Martinent, G. (2015). Trajectories of psychological states of women elite fencers during the final stages of international matches. *Journal of Sports Sciences, 34*(9), 836-842. https://doi.org/10.1080/02640414.2015.1075056

Czajkowski, Z. (2009). The Essence and Importance of Sense of Timing in Fencing. *Studies in Physical Culture and Tourism, 16*(3), 241-247. https://wbc.poznan.pl/publication/110559

Johne, M., Poliszczuk, T., Poliszck, D., & Dabrowska-Perzyna, A. (2013). Asymmetry of Complex Reaction Time in Female ÉPÉE Fencers of Different Sports Classes. *Polish Journal of Sport and Tourism, 20*(1), 25-34. https://doi.org/10.2478/pjst-2013-0003

Nathanael, O. (2017). Reactive stress tolerance in elite athletes: Differences in gender, sport type, and competitive level. *Cognition, Brain, Behavior, 21*(3), 189-202. https://doi.org/10.24193/cbb.2017.21.11

Schuhfried, G. (2016). *Manual Determination Test* (Version 41). In G.Schuhfried, Vienna Test System Manual (pp. 5-6). Austria.

Fink, E., Patalay, P., Sharpe, H., Holley, S., Deighton, J., & Wolpert, M. (2015). Mental Health Difficulties in Early Adolescence: A Comparison of Two Cross-Sectional Studies in England From 2009 to 2014. *Journal of Adolescent Health, 56*(5), 502-507. https://doi.org/10.1016/j.jadohealth.2015.01.023

Haugland, S., Wold, B., Stevenson, J., Aaroe, L. E., & Woynarowska, B. (2001). Subjective health complaints in adolescence: A cross-national comparison of prevalence and dimensionality. *European Journal of Public Health, 11*(1), 4-10. https://doi.org/10.1093/eurpub/11.1.4

Jones, D. C. (2001). Social Comparison and Body Image: Attractiveness Comparisons to Models and Peers Among Adolescent Girls and Boys. *Sex Roles, 9*(10), 645-664. https://doi.org/10.1023/A:1014815725852

Verma, J. P. (2016). *Descriptive Profile. In J. P. Verma, Sports Research With Analytical Solution Using SPSS* (pp. 31-33). Hoboken, New Jersey: John Wiley & Sons, Inc. https://doi.org/10.1002/9781119206767.ch2

Piepiora, P. (2021). Personality Profile of Individual Sports Champions. *Brain and Behavior, 11*(6), e02145. https://doi.org/10.1002/brb3.2145

Pahan, M. K., & Singh, M. K. (2021). A Comparative Study of Cognitive Abilities among Tribal and Non-Tribal Young Athletes of Jharkhand. *The 21st Bi-Annual Conference of International Society of Comparative Physical Education and Sport* (p. 104). Thiruvananthapuram, Kerala, India: Fundación Civil EDUFISADRED Educación Física, Recreación Y Deporte – ISCPES – Lakshmibai National College of Physical Education.

Committee on Sports Medicine and Fitness. (2000). Intensive Training and Sports Specialization in Young Athletes. *American Academy of Pediatrics, 106*(1), 154-157. https://doi.org/10.1542/peds.106.1.154

Launay, F. (2015). Sports-Related Overuse Injuries in Children. *Orthopaedics & Traumatology: Surgery & Research, 101*(1), S139-S147. https://doi.org/10.1016/j.otsr.2014.06.030

Travassos, B., Araujo, D., & Davids, K. (2017). Is futsal a donor sport for football?: exploiting complementarity for early diversification in talent development. *Science and Medicine in Football, 2*(1), 66-70. https://doi.org/10.1080/24733938.2017.1390322

Buckley, P. S., Bishop, M., Kane, P., Ciccotti, M. C., Selverian, S., Exume, D., et al. (2017). Early Single-Sport Specialization: A Survey of 3090 High School, Collegiate, and Professional Athletes. Orthopaedic *Journal of Sports Medicine, 5*(7), 1-7. https://doi.org/10.1177/2325967117703944

IGNOU. (2010). Development During Adolescence. In IGNOU, Developmental Psychology (p. 5). New Delhi: IGNOU. https://doi.org/10.21474/ijar01/11270

Allen, B., & Waterman, H. (2019). Stages of Adolescence. Retrieved 01 2022, 07, from *Healthy Children*: https://www.healthychildren.org/English/ages-stages/teen/Pages/Stages-of-Adolescence.aspx

Thompson, P. J. (2009). *Developing the Athlete. In P. J. Thompson, Introduction to Coaching: The Offecial IAAF Guide to Coaching Athletics* (pp. 43-61). Lincolnshire, United Kingdom: Warners Midlands plc.

Laborde, S., Guillén, F., & Mosley, E. (2016). Positive personality-trait-like individual differences in athletes from individual- and team sports and in non-athletes. *Psychology of Sport and Exercise,* 26, 9-13. https://doi.org/10.1016/j.psychsport.2016.05.009

ТОЛЕРАНТНІСТЬ ДО РЕАКТИВНОГО СТРЕСУ У УЧАСНИКІВ ДОПІДЛІТКОВОГО СПОРТУ: ПОРІВНЯННЯ ШЕСТИ ІНДИВІДУАЛЬНИХ БЕЗКОНТАКТНИХ ВИДІВ СПОРТУ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 3 табл., 3 рис., 38 джерел.

Мета дослідження. Метою дослідження було вивчити, як відрізняється стійкість до реактивного стресу в передпідлітковому віці в шести різних безконтактних видах спорту.

Матеріали та методи. Стрільба з лука, їзда на велосипеді, стрільба, плавання, легка атлетика та важка атлетика – це безконтактні види спорту, обрані для дослідження. У дослідженні взяли участь 180 спортивних кадетів із Державного товариства сприяння спорту Джаркханда, віком від 11 до 13 років. Для оцінки стійкості до реактивного стресу використовували форму детермінаційного тесту S1 за Віденською тестовою системою. Для дослідження були відібрані змінні, такі як процентильні ранги правильних, неправильних і пропущених відповідей, а також оцінка середнього часу реакції. Було проведено порівняння між десятками змінних у реактивній стресостійкості шести вибраних спортивних дисциплін. Основний ефект визначали за допомогою тесту Краскала-Уолліса, тоді як попарні пост-хок порівняння проводили за допомогою U-критерію Манна-Уітні. Рівень значимості був встановлений на рівні 0,05.

Результати. Не було значущих відмінностей у процентильному рейтингу правильного, неправильного та середнього часу реакції між вибраними видами спорту. За процентним рейтингом неправильних відповідей такі види спорту, як стрільба з лука, стрільба та важка атлетика, значно відрізняються від плавання.

Висновок. Згідно з висновками, види спорту, в яких відстань долається за рахунок вироблення імпульсу тіла, менш схильні до неконтрольованої поведінки під час спортивних змагань.

Ключові слова: реактивна стресостійкість, юні спортсмени, стрільба з лука, велоспорт, стрільба, плавання, легка атлетика, важка атлетика.

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ORIGINAL SCIENTIFIC ARTICLE

JUMP MOVEMENT SKILLS PATTERN AMONG INDONESIA MENTALLY RETARDED CHILDREN USING D-MAT

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Abstract

The study purpose. Currently, the study was to get the pattern of jumping movement skills for mentally retarded children using D-Mat. It is as part of technology advanced to support physical activity and sport. While mentally retarded children have different ways to jump with normal children.

Materials and methods. The method used qualitative research using observational design. Participants are mentally retarded children aged 6-11 years who are divided into two groups, namely ages 6-8 years and ages 9-11 years. The data were collected through a process of observation and video recording. While the validation of the jumping movement test used observational and test-rater from 2 experts for the needs of mentally retarded children. Data analysis techniques used the Kruskal-Wallis test with a significant level of $p < 0.05$ and descriptive statistics.

Results. The findings concluded that the jumping movement pattern of mentally retarded children aged 6-11 years is forward jumping movement. They are easy to do it using D-Mat. This movement model is quite stable and easy to master.

Conclusions. Each component of the movement also shows fairly good stability according to the characteristics and needs of each child.

Keywords: children, D-Mat, jump, mentally retarded.

Introduction

Mentally retarded children have uniqueness and characteristics that cannot be equated with normal children in developing jumping movement skills. They have significant limitations in both intellectual functioning (Tajalli et al., 2013) and adaptive behaviour such as conceptual understanding, social skills and adaptive practice. They are also characterized by low fundamental movement skills (Maïano et al., 2019). While it is important to relate with the physical activity and health for children (Shams et al., 2021; Anderson et al., 2017). However, these limitations do not mean that they are not able to make good jumping movements. It is a basic skill that must be mastered by mild type mentally retarded children to help carry out daily activities, besides that jumping movement skills are also basic in the mastering of sports such as athletics, swimming or physical activity in sports (Wouters et al., 2019).

The results of observations at the Special Elementary School in Palembang in 2018 and 2019, mild mentally retarded children still have experience difficulties in doing basic jumping movements. Where jumping is a movement of lifting the body from one point to another using one leg as support. While the results of observations on mild type of mentally retarded children aged 7-12 years who participated in the development of athletic sports at the State University of Jakarta were also still difficult to jump. The results of the overall analysis of the observations concluded that mild types of mentally retarded children have quite good physical development for the level of limitations they have, but they are still stiff, afraid and unable to have a habit of balancing their bodies to jump.

Thus, mentally retarded children need special tests in physical fitness (Broadhead & Church, 2016; Addriana et al., 2019; Jaakkola et al., 2019; Rahmati Aran & Dehghanizade, 2020). Schools in Italy use an education system that does not discriminate against people with disabilities (Caldin, 2014). In this case, teachers must understand the implementation of education for schools with special needs (Demirok & Besgul, 2015).

Research related to movement skills, both basic movements in sports such as jumping, or other physical activities, is still not an interesting topic for researchers recently. It related to children with disabilities is often related to the concept of their social interactions and activities in their daily lives. However, the current study focuses on movement jumping to support their sports activities in ordinary schools that use D-Mat (Digital Matras) have not been carried out. Therefore, the gap between this study and previous research is seen in the concept of the jumping movement skill pattern using the D-Mat design which has previously been adjusted to the needs and limitations. The use of the D-Mat is a form of utilizing technological devices that have been used in the sports field. Physical activities for children with intellectual disabilities can be combined with entertainment, technology and education systems (Dandashi et al., 2015; Kucera, 2015; Růžičková & Hordějčuková, 2015; Chen et al., 2019). Technology has become a trend and innovation in sports (Kos et al., 2018). It appears in various activities such as games, competitions, training (Ratten, 2020), digital games for physical activity (Barnett et al., 2012), multimedia training used the technology device (Jinding, 2018; Sukendro et al., 2020; Sun, 2021).

Thus, the *purpose of the study* is to get the pattern of jumping movement skills for mentally retarded children using D-Mat. In this study, D-Mat has designed using technology device to use in jumping movement training for mentally retarded children in the school. Moreover, the study can contribute to the training program of basic movement in the special school, especially mild mentally disabled children.

Materials and methods

Research Approach

The research is a qualitative method that used an observational design. In this study, the research activity was aimed at observing the jumping movement skills patterns of mentally retarded children in Palembang without any changes to the characteristics and situations of the physical activity learning process in special schools (Creswell & Creswell, 2018). The observational design uses a cohort study because the group of participants involved in this study are mentally retarded children aged 6-11 years or mentally retarded children equivalent to the level of elementary school children in Palembang.

Participants

The participant is taken using the purposive sampling (non-probability sampling) which is 40 Indonesian children at a special school. The criteria for the participants were 1) children who have an IQ between 68-53 (Binet scale) or an IQ of 69-55 (Wescheler scale), 2) they do not have physical problems but have a slightly slower physical development than average children, 3) the child has a height and weight that is not different from other children, even physically difficult to distinguish from normal children. The body weight is between 20-30 kg. the participant divided into 2 groups, i.e 6-8 years (n = 20), and 9-11 years (n = 20). The observation process of jumping movement skills is helped by the parent.

Process of Collecting Data

Jumping movement skills of mentally retarded children were recorded using video. The jumping movements skills assessment provides a score in the form of a True-False form test, where true scores are scored as 1 (one) and wrong is 0 (zero). There are three types of jumping movements, namely jumping forward, backward, and sideways. The components of mastery of basic jumping movement for mentally retarded children are assessed through 6 components, consisting of 1) leg posture 2) knee movement, 3) hip movement. 4) body movements, 5) hand movements, 6) harmony movement. Table 1 presented the variables and their components of jumping movement skills.

Table 1. Aspect and Components of Jumping Movement Skills

The aspect of Jumping Movement Skills	Components
Jumping Forward Jumping Backward Jumping sideways	1. leg posture, 2. knee movement, 3. hip movement, 4. body movements, 5. hand movements, 6. harmony movement

Procedure

The research process begins with technical testing activities in preliminary research. Technical trials for the assessment of jumping movement skills were implemented on other mentally retarded students (n = 10) who were not research subjects with the same characteristics for 2 months (August - September 2020). The technical test activities were recorded as data analysis documents. Whereas for reliability activities used a test rater who is an expert in cases of mentally retarded children. The two evaluators of this instrument were independent colleagues who were also involved during the observation process of research activities. Thus, the assessment process for participants has valid trust and reliability values. The results of the reliability assessment showed a high level of reliability, namely 0.867.

Testing of participants is carried out at school. The testing process has been scheduled according to the time of the study from October 2020 to March 2021. The time of the research did not change the physical learning activities and sports of mentally retarded students at school. Students will be guided and directed to use D-Mat to perform jumping movements. During the implementation of the activity, peers also provide observations of the results of student movements. The camera is installed to record all the activities of mentally retarded students. The results of recordings and observations of peers or researchers are evaluated together for analysis related to jumping movement patterns.

Statistical Analysis

The jumping movement skill difference test was carried out by comparison between age groups using the Kruskal-Wallis test with a significant level of $p < 0.05$. Meanwhile, the data of the test results per group used statistical descriptive.

Results

The results of the data analysis show that the level of group jumping movement of mentally retarded children has variations according to their physical conditions and needs. The results of descriptive calculations between the two groups are as follows.

Table 2. The mean and standard deviation of two groups in the jumping movement skills aspect

An aspect of Jumping Movement	6-8 Age Years Group			9-11 Age Years Group		
	N	M	Sd	N	M	Sd
Jumping Forward	20	19.78	2.85	20	21.83	3.68
Jumping Backward	20	17.57	2.44	20	19.77	3.08
Jumping Sideways	20	18.88	2.76	20	18.05	2.96

Significant at 0.05 level

Table 2 shows the result of mean and standard deviation in process of jumping movement practice for mentally retarded in each aspect of jumping movements; 1) 6-8 age years group; jumping forward 19.78±2.85, jumping backwards 17.57 ± 2.44, and jumping sideways 18.88 ± 2.76. 2) 9-11 age years group; jumping forward 21.83±3.68, jumping backwards 19.77 ± 3.08, and jumping sideways 18.05 ± 2.96.

The group with an age range of 6-8 years conclude that mentally retarded children have more forward jumping movement patterns, followed by sideways and backward jumps. Meanwhile, mentally retarded children aged 9-11 years have a jump movement pattern that has a forward jump movement pattern, then followed by jumping backwards and sideways. This means that the pattern formed for the jumping activity of mentally retarded children aged 6-8 years or aged 9-11 years has the stability for forwarding jumping movement (fig. 1).

Statistically significant differences ($p < 0.05$) were observed for all the components of jumping forward movement ($p = 0.318$). For 6-8age years, the hand movement is easy to do, while for 9-11 age years, the hand movement and harmony movement is easy to do by mentally retarded (fig. 2).

Statistically significant differences ($p < 0.05$) were observed for all the components of jumping forward movement ($p = 0.187$). For 6-8 age years, the leg posture is easy to do, while for 9-11 age years, the leg posture, hand movement and harmony movement are easy to do by mentally retarded (fig. 3).

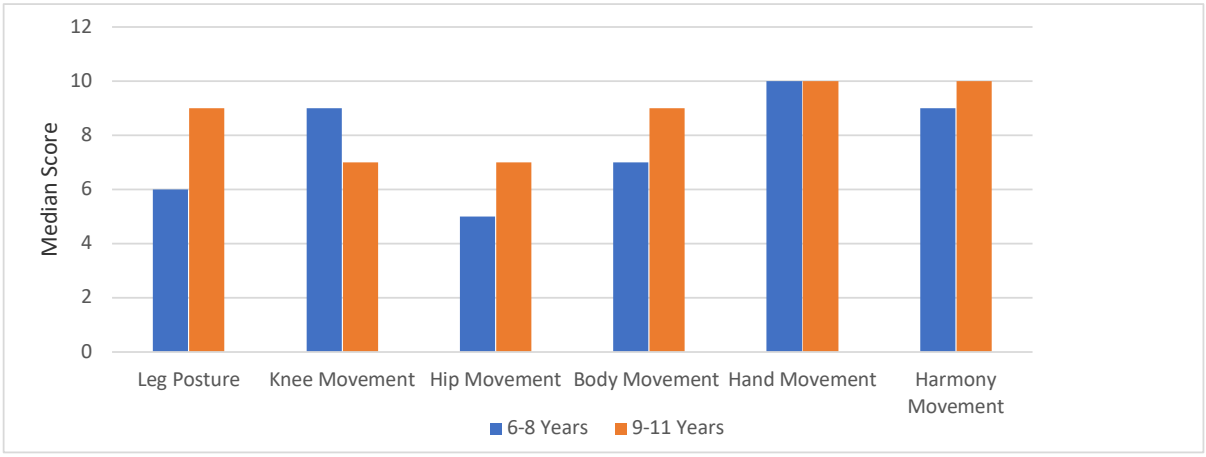

Figure 1. Components of Jumping Forward Movement by Age Group

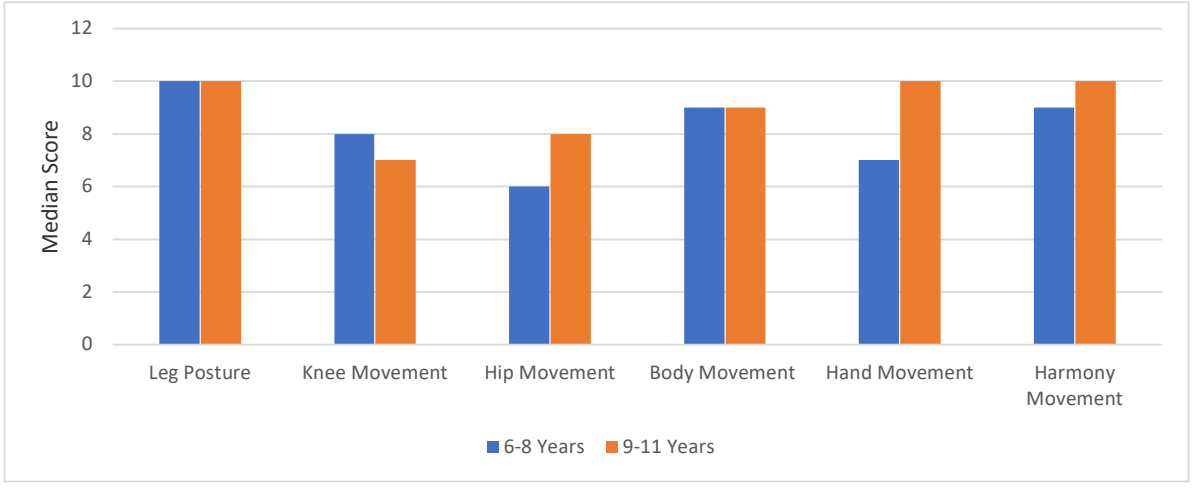

Figure 2. Components of Jumping Backward Movement by Age Group

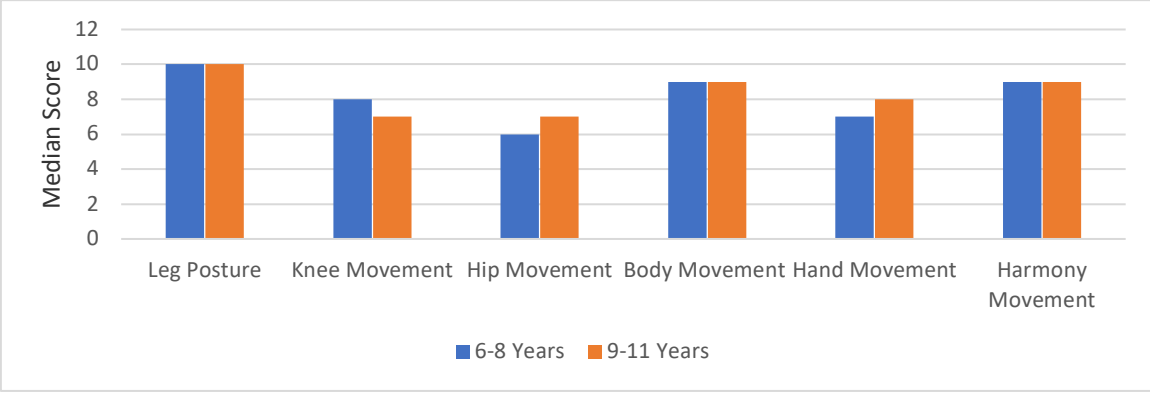

Figure 3. Components of Jumping Sideways Movement by Age Group

Statistically significant differences ($p < 0.05$) were observed for all the components of jumping forward movement ($p = 0.267$). For 6-8 age years and 9-11 age years, the leg posture influences the jumping backward movement by mentally retarded.

Discussion

The pattern of jump movements from the results of data analysis during the test shows that both the 6-8 age year group or 9-11 age year group is dominated by forward jumping movements with variations, namely jumping with the hand at the waist, jumping with swinging hands, jumping with clapping, jump with your arms outstretched, jump with your arms crossed forward and shout "Banzai". For the pattern of the jump back movement, the variations that are formed are jumping backwards with a swinging hand and jumping backwards by clapping the hands. While the pattern of the jump movement to the side that is formed is a combination jump with swinging hands, combination jump by clapping, and combination jumping with outstretched hands.

It is known that jumping for mentally retarded children is a continuous asymmetric skill and involves taking off and landing with the same foot. They are required to have greater leg strength and dynamic balance so that the resulting jump can be successful and can combine with other basic movements. Also, the help of tools for basic movement training is very important. D-Mat provides an easy way for coaches to guide mentally retarded children. So, technology becomes a new pattern in providing training media (Sharples & Whelan, 2020). Many a tool or technology device is for the jump movement training (Masci et al., 2013; Wiksten et al., 2002).

The finding shows that the jumping skill pattern of mentally retarded children has good basic skills, because of balance, movement control, and locomotor so that they can perform forward and backward movements (Zeng et al., 2019; Gandotra et al., 2020). Every movement for children should be fun (Sumantri, 2015). Coordination between the arms and legs plays an important role in controlling movement (DiRocco et al., 2016). In this case, the motor pattern influences the jump movement (Matsuzaki & Hentona, 1994). Each jump movement in children also shows a different level. This could be due to gender differences (Bryant et al., 2014; Hardy et al., 2010).

Another weakness found in this study referred to the activity of jumping using one leg that was not yet formed or supported the body's objections. Even though, this skill is also important in body management so that the level of balance or foothold can be perfectly formed. Lots of sports or children's daily activities use jumping movements. Thus, the results of this study also provide a major contribution to the jumping movement skills of mentally retarded children who support their daily activities that have been limited or slow. Moreover, mentally retarded children also take a long time to resolve new situations. They showed their best reactions when they followed the routine and consistently experienced it. Mentally retarded children cannot face an activity or task for a long time. They are less able to consider things, distinguish between good and bad and distinguish right from wrong. This is due to their limited abilities so that mentally retarded children cannot first imagine the consequences of an action.

This study trains how to build consistency in the actions given to mentally retarded children in mastering basic movement skills. The treatment process must be given one by one so that they can develop their physical abilities and knowledge of each basic movement skill. From the division of the two age groups, it is known that children aged 9-11 years have been able to show the development of mastery of the jumping movement not only forwards, but also backward movements that are more balanced.

Conclusions

Based on the conclusion of the research results, the D-Mat makes it easy for mentally retarded children to jump because all the information needed is presented on the digital mat. From the three aspects of jumping, mentally retarded children have a level of balance and harmony in making the jump forward. The combination between the limbs is also more aligned, causing 5 variations of the forward jumping movement. The implication of this research can be seen from the understanding of the concept of mastery of basic jumping movements that must be mastered first by mentally retarded children is jumping forward. Because this movement is easier and the balance of the body can be maintained stably. This way, the coaches at the special school can proceed with the backward and side jump design concept. Therefore, this research can still be developed again with a combination of the concept of various types of games that can be enjoyed and provide stimulation to mentally retarded children in carrying out physical activities. Besides, the results of this

study can also be followed by an in-depth study related to another basic jumping.

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Conflict of interest

There is no conflicts of interest to declare.

References

Tajalli, P., Hooman, H. A., A.Afrooz, G. H., & Ghobaribonab, B. (2013). Examine the Presence of ADHD in Families of Students with/without ADHD. *Procedia – Social and Behavioral Sciences,* 84, 346-350. https://doi.org/10.1016/j.sbspro.2013.06.564

Maïano, C., Hue, O., & April, J. (2019). Effects of motor skill interventions on fundamental movement skills in children and adolescents with intellectual disabilities: a systematic review. *Journal of Intellectual Disability Research, 63*(9), jir.12618. https://doi.org/10.1111/jir.12618

Shams, A., Hardy, L. L., Vameghi, R., Loovis, E. M., & Shamsipour Dehkordi, P. (2021). Prevalence of fundamental movement skill proficiency among Iranian children aged 2.5–14 years. *Journal of Science and Medicine in Sport, 24*(1), 74-79. https://doi.org/10.1016/j.jsams.2020.09.014

Anderson, M. K., Grier, T., Canham-Chervak, M., Bushman, T. T., Nindl, B. C., & Jones, B. H. (2017). Effect of Mandatory Unit and Individual Physical Training on Fitness in Military Men and Women. *American Journal of Health Promotion, 31*(5), 378-387. https://doi.org/10.1177/0890117116666977

Wouters, M., Evenhuis, H. M., & Hilgenkamp, T. I. M. (2019). Physical activity levels of children and adolescents with moderate-to-severe intellectual disability. *Journal of Applied Research in Intellectual Disabilities, 32*(1), 131-142. https://doi.org/10.1111/jar.12515

Broadhead, G. D., & Church, G. E. (2016). Influence of Test Selection on Physical Education Placement of Mentally Retarded Children. *Adapted Physical Activity Quarterly, 1*(2), 112-117. https://doi.org/10.1123/apaq.1.2.112

Addriana, B. B., Tandiyo, R., Soegiyanto, S., & Sulaiman, S. (2019). Evaluation of Physical Fitness for Students with Mentally impaired Aged 10-12 years in Poso Regency, Sulawesi Tengah Province, Indonesia. *International Journal of Multicultural and Multireligious Understanding, 6*(4), 581. https://doi.org/10.18415/ijmmu.v6i4.1135

Jaakkola, T., Hakonen, H., Kankaanpää, A., Joensuu, L., Kulmala, J., Kallio, J., Watt, A., & Tammelin, T. H. (2019). Longitudinal associations of fundamental movement skills with objectively measured physical activity and sedentariness during school transition from primary to lower secondary school. J*ournal of Science and Medicine in Sport, 22*(1), 85-90. https://doi.org/10.1016/j.jsams.2018.07.012

Rahmati Aran, M., & Dehghanizade, J. (2020). Effect of Training on the Balance and Coordination of the Mentally Retarded Children. *International Journal of Motor Control and Learning, 2*(2), 15-23. https://doi.org/10.29252/ijmcl.2.2.15

Caldin, R. (2014). Inclusive social networks and inclusive schools for disabled children of migrant families. *Alter, 8*(2), 105-117. https://doi.org/10.1016/j.alter.2014.02.001

Demirok, M. S., & Besgul, M. (2015). Examination of Preschool Teacher and Teacher of Mentally Retarded Candidates' Opinions about Mainstreaming. *Procedia – Social and Behavioral Sciences,* 190, 169-179. https://doi.org/10.1016/j.sbspro.2015.04.932

Dandashi, A., Karkar, A. G., Saad, S., Barhoumi, Z., Al-Jaam, J., & El Saddik, A. (2015). Enhancing the Cognitive and Learning Skills of Children with Intellectual Disability through Physical Activity and Edutainment Games. *International Journal of Distributed Sensor Networks, 11*(6), 165165. https://doi.org/10.1155/2015/165165

Kucera, V. (2015). Comparative Analysis of Teaching Methods of Making Web Pages. *Procedia – Social and Behavioral Sciences,* 171, 945-949. https://doi.org/10.1016/j.sbspro.2015.01.213

Růžičková, K., & Hordějčuková, T. (2015). Modern Devices to Support Early Development of Children with Visual Impairment. *Procedia – Social and Behavioral Sciences,* 171, 950-960. https://doi.org/10.1016/j.sbspro.2015.01.214

Chen, J., Wang, G., Zhang, K., Wang, G., & Liu, L. (2019). A pilot study on evaluating children with autism spectrum disorder using computer games. *Computers in Human Behavior,* 90, 204-214. https://doi.org/10.1016/j.chb.2018.08.057

Kos, A., Wei, Y., Tomažič, S., & Umek, A. (2018). The role of science and technology in sport. *Procedia Computer Science,* 129, 489-495. https://doi.org/10.1016/j.procs.2018.03.029

Ratten, V. (2020). Sport technology: A commentary. *Journal of High Technology Management Research, 31*(1), 100383. https://doi.org/10.1016/j.hitech.2020.100383

Barnett, L. M., Hinkley, T., Okely, A. D., Hesketh, K., & Salmon, J. (2012). Use of electronic games by young children and fundamental movement skills? *Perceptual and Motor Skills, 114*(3), 1023-1034. https://doi.org/10.2466/10.13.PMS.114.3.1023-1034

Jinding, L. (2018). The computer multimedia technology application in basketball teaching and training in colleges and universities. *Journal of Advanced Oxidation Technologies, 21*(2). https://doi.org/10.26802/jaots.2018.08200

Sukendro, S., Habibi, A., Khaeruddin, K., Indrayana, B., Syahruddin, S., Makadada, F. A., & Hakim, H. (2020). Using an extended Technology Acceptance Model to understand students' use of e-learning during Covid-19: Indonesian sport science education context. *Heliyon, 6*(11), e05410. https://doi.org/10.1016/j.heliyon.2020.e05410

Sun, Q. (2021). Current school sports intelligence system based on artificial intelligence and internet of things technology. *Advances in Intelligent Systems and Computing,* 1244 AISC, 625-632. https://doi.org/10.1007/978-3-030-53980-1_92

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches fifth edition.* SAGE Publications Inc.

Sharples, S. A., & Whelan, P. J. (2020). An interphyletic tool kit to study locomotor function: Past, present, and future directions. *In The Neural Control of Movement* (pp. xxi–xlv). https://doi.org/10.1016/b978-0-12-816477-8.09997-x

Masci, I., Vannozzi, G., Bergamini, E., Pesce, C., Getchell, N., & Cappozzo, A. (2013). Assessing locomotor skills development in childhood using wearable inertial sensor devices: The running paradigm. *Gait and Posture, 37*(4), 570–574. https://doi.org/10.1016/j.gaitpost.2012.09.017

Wiksten, D. L., Spanjer, J., & LaMaster, K. (2002). Effective Use of Multimedia Technology in Athletic Training Education. *Journal of Athletic Training, 37*(4 Suppl), S213-S219. http://www.ncbi.nlm.nih.gov/pubmed/12937547

Zeng, N., Johnson, S. L., Boles, R. E., & Bellows, L. L. (2019). Social-ecological correlates of fundamental movement skills in young children. *Journal of Sport and Health Science, 8*(2), 122-129. https://doi.org/10.1016/j.jshs.2019.01.001

Gandotra, A., Kotyuk, E., Szekely, A., Kasos, K., Csirmaz, L., & Cserjesi, R. (2020). Fundamental movement skills in children with autism spectrum disorder: A systematic review. *In Research in Autism Spectrum Disorders,* 78, 101632. https://doi.org/10.1016/j.rasd.2020.101632

Sumantri, M. S. (2015). Learning Model of Fundamental Long Jump Movement Based On Game Approach. Indonesian *Journal of Early Childhood Education Studies, 4*(1), 35-41. https://doi.org/10.15294/IJECES.V4I1.9451

DiRocco, P. J., Clark, J. E., & Phillips, S. J. (2016). Jumping Coordination Patterns of Mildly Mentally Retarded Children. *Adapted Physical Activity Quarterly, 4*(3), 178-191. https://doi.org/10.1123/apaq.4.3.178

Matsuzaki, Y., & Hentona, T. (1994). Motor Pattern During the Standing Long Jump in Individuals with Mental Retardation. *In Adapted Physical Activity* (pp. 131-136). Springer Japan. https://doi.org/10.1007/978-4-431-68272-1_21

Bryant, E. S., Duncan, M. J., & Birch, S. L. (2014). Fundamental movement skills and weight status in British primary school children. *European Journal of Sport Science, 14*(7), 730-736. https://doi.org/10.1080/17461391.2013.870232

Hardy, L. L., King, L., Farrell, L., Macniven, R., & Howlett, S. (2010). Fundamental movement skills among Australian preschool children. *Journal of Science and Medicine in Sport, 13*(5), 503-508. https://doi.org/10.1016/j.jsams.2009.05.010

МОДЕЛЮВАННЯ НАВИЧОК СТРИБКОВОГО РУХУ ЗА ДОПОМОГОЮ D-MAT ТЕХНОЛОГІЇ СЕРЕД ДІТЕЙ З ПОРУШЕННЯМ ІНТЕЛЕКТУАЛЬНОГО РОЗВИТКУ В ІНДОНЕЗІЇ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 6 с., 2 табл., 3 рис., 32 джерела.

Мета дослідження полягала в тому, щоб отримати, за допомогою D-Mat, модель навичок стрибкових рухів для дітей з порушенням інтелектуального розвитку. D-Mat – передова технологія для підтримки фізичної активності та спорту, вичення закономірностей формування рухових навичок, це є важливим у зв'язку з тим, що діти з порушенням інтелектуального розвитку мають різні способи стрибати у порівнянні з нормальними дітьми.

Матеріали та методи. Використано якісне дослідження із застосуванням методу спостереження. Учасниками є діти з порушенням інтелектуального розвитку віком 6-11 років, які поділяються на дві групи, а саме вік 6-8 років та вік 9-11 років. Дані були зібрані у процесі спостереження та відеозйомки. При валідації стрибко-рухового тесту використовувалися спостереження та тест-рейсер від 2-х експертів. Для аналізу даних використовували тест Краскала-Уолліса зі значущим рівнем $p < 0,05$ та описову статистику.

Результати. Встановлено, що модель стрибкового руху у дітей з порушенням інтелектуального розвитку у віці 6-11 років є стрибковим рухом уперед. Його легко змоделювати за допомогою D-Mat. Ця модель руху є досить стійкою і легкою для освоєння.

Висновки. Кожен компонент руху має досить хорошу стійкість відповідно до особливостей і потреб кожної дитини.

Ключові слова: діти, D-Mat, стрибок, розумово відсталі.

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ORIGINAL SCIENTIFIC ARTICLE

EFFECT OF THE EIGHT-WEEK AGILITY DEVELOPMENT PROGRAM IN ELEMENTARY SCHOOL STUDENTS

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Abstract

The study purpose. The research was conducted in order to determine the effect of an eight-week agility development program (ADP) in elementary school students.

Materials and methods. 107 fifth grade elementary school students from four classes randomly marked as agility development program (ADP) group (n = 55) or control (CON) group (n = 52) took part in the testing. The students had two classes of physical education per week, which is a total of 16 classes in eight weeks. ADP lasting 15 minutes was conducted within the main part of the physical education class. Both groups attended physical education classes, except that the control group had activities without a special agility development program. Two-tailed independent t-test was used to analyze differences in agility between the ADP and the CON and the change in the performance from pre- to posttests between groups. Two-tailed paired t-test was used to analyze changes in agility performance between pre- and posttests within both groups.

Results. Compared with the CON, the ADP group showed significantly better performances ($p \leq 0.05$) in Zig-zag test, Illinois Agility Run test, Agility T test and Arrowhead Agility test after the training period, but not in Balsom agility test ($p > 0.05$).

Conclusions. The positive effect of the 8-week agility development program (ADP) on improving agility was determined. Therefore it can be concluded that the implemented program for the development of agility can contribute to the improvement of physical performance and various skills needed for the proper development of children.

Keywords: physical education, children, agility training, motor abilities.

Introduction

In children, from an early age, daily physical activity is very important, mostly aerobic type of moderate to high intensity, while, usually after puberty, they include as well anaerobic physical activity, which creates the basis of physical shape and health status for future life in adulthood (Milenković, 2021). Physical education as an integral part the school system is the most extensive and most organized type of physical exercise for the largest number of children and the youth, and for many of them it is the only organized physical exercise (Gadžić, 2019). Therefore, regular participation in physical education classes is a potential opportunity for the development of physical abilities, knowledge and skills (Faigenbaum et al., 2015), because quality professional work with students can affect the improvement of their physical performance and muscle strength as a basis for participation in games, sports, and other physical activities (Behringer et al., 2011). Besides, adequate school physical education programs in today's technologically advanced world can be a solution to the frequent negative phenomenon in the form of physical inactivity in children, which often creates health problems such as obesity and hypertension (Katzmarzyk et al., 2015; Brown et al., 2019; Aguilar-Cordero et al., 2020; Stavridou et al., 2021), although the research in terms of prevention of these problems increasingly indicates the need for additional activity along with physical education in schools (Cvetković et al., 2018; Steene-Johannessen et al. al., 2020).

The development of physical abilities is one of the areas which the contents of the physical education program are directed to (Milenković, 2021). One of the abilities important for the proper physical development of children is agility, a very complex ability that correlates with other factors such as coordination, strength, speed, explosiveness, endurance, balance (Sekulić et al., 2013). It can be defined as the ability to change

the direction quickly without losing balance and reducing speed (Lemmink, Elferink-Gemser & Wisscher, 2004). Agility represents a combined ability of speed, strength and coordination, and when conjoined with flexibility, result in mobility or quality of quick movement performance, together with timeliness and coordination in the full range of motion (Bompa, 2006).

The nature of agility is multifactorial, so apart from the cognitive element, anticipation and decision-making (Young, James & Montgomery, 2002; Gabbett, Kelly & Sheppard, 2008; Sheppard et al., 2006), biomechanical element is also of great importance for skillful movement (Young & Farrow, 2006). Agility is very often seen in the scientific literature as a part of the SAQ block (speed, agility, quickness) which is also made up of speed and explosiveness (Köklü et al., 2015; Brown & Ferrigno, 2005). These three abilities are highly related and the improvement of one of them affects the improvement of the other two (Acar & Eler, 2019).

Agility can be manifested in various forms, from the movement of one part of the body, to the movement of the entire muscular system at high speed in a certain direction (Sopa & Pomohaci, 2016). Agile movements in any direction are not performed at a constant speed over the entire distance, but are divided into the phase of acceleration, maintenance of maximum speed and deceleration (Plisk, 2000). In addition to a good result in conducting motor activity and neutralizing opponents (in play or competition), the optimal level of agility reduces the possibility of injury and allows a high level of manipulative skills (Verstegen & Marcello, 2001).

Agility development programs are very important in physical education, primarily due to the fact that agility is considered a combination of certain basic abilities (Bompa, 2006) and thus has a multiple effect on the motor status of children. Also, the level of competence in basic motor skills significantly depends on the level of agility development (Haga, 2008; Aribowo, Hidayah & Rumini, 2019). One of the sensitive phases of agility development is the period from the seventh year of life to the beginning of puberty (Bijelić & Simović, 2005), which indicates the need to use this period effectively to improve this important segment in physical performance. Therefore, the aim of this research is to determine the effects of programs for the development of agility within the process of teaching of physical education.

Materials and methods

Experimental approach to the problem

The research is designed to determine the effect of an eight-week agility development program (ADP) in elementary school students. Of the four fifth grade classes, two classes were randomly designated as the ADP group, while the other two were the control (CON) group. Both groups attended physical education classes, with the control group having activities without a special agility development program. The classes were held by the same physical education teacher. Before the beginning of the program, the initial testing was performed, and after the end, the final testing of both groups.

Study participants

107 students (Table 2) of the fifth grade of elementary school from four classes randomly marked as Agility development program (ADP) group (n = 55 – 30 boys and 25 girls) or control (CON) group (n = 52 – 25 boys and 27 girls). took part in the testing. There were no chronic diseases or major injuries, primarily of the lower extremities, in the health records of the students. The permission of the parents of all students to participate in this research was obtained, as well as the consent of the children themselves. The research organized in accordance with the recommendations for clinical research given by the World Health Organization (WHO) within the Helsinki Declaration (2013).

Testing procedure

The testing was performed in the gym during the physical education classes with the students wearing adequate sports equipment. Since testing is a part of the regular physical education classes during each school year, students were generally experienced in such a procedure. However, a week before the initial testing, the students and their teacher were practicing all the tests that were used later, in order to ensure the accuracy of the testing procedure itself. A trial test was also organized in order to prepare the students for the whole procedure that was going to be applied during the experimental testing. Two days after the trial one, the initial testing was carried out, and eight weeks later the final one was performed. A warm-up of 15 minutes was performed before each testing. Each of the tests was repeated three times, and the best result was taken for further analysis. After completing each test and before moving on to the next one, there was a break of 5-8 minutes to avoid negative effects on testing caused by fatigue. Height and body weight were measured using the standard techniques with a stadiometer and standard physician's scale. Furthermore, the body mass index (BMI) was calculated using the standardized equation mass/height2 (kg/m2) (Table 1).

Five agility tests (Topend Sports) already proved by the previous research to be reliable and valid for assessing this ability were used:

- Zig-zag test (Kutlu & Doğan, 2018);
- Ilinois agility run test (Hachana et al., 2014; Kutlu, Yapici & Yilmaz, 2017);
- Agility T test (Pauole et al., 2000; Fessi et al., 2016);
- Balsom agility test (Wrigley, 2016);
- Arrowhead agility test (Lockie & Jalilvand, 2017; Rago et al., 2020).

The Witty Timing System (Microgate, Bolzano, Italy) was used to measure the time when performing agility tests.

Training Procedure

The program is specially designed for the students of this age. They had two classes of physical education per week, which is a total of 16 classes in eight weeks. Within the main part of each class, 15 minutes were used for specialized ADP. The exercises were aimed at improving elementary movements with a change of direction at an angle of 90° and over 90°. It has been worked on the development of technique in changing conditions; forward / backward and sideways movements were used. Tasks were performed by manipulating objects and in the presence of the opponent in order to achieve optimal speed and maximum force of muscle contraction. In order to avoid monotony, various mobile games

were played, which are an effective form for the development of agility in the children of this age (Skitnevskiy et al., 2020). By working on the development of agility it was supposed to increase the ability to activate motor units and agonist muscle groups faster and more completely.

The extent and intensity of the workload, as well as the breaks between the repetitions of exercises and series, were adjusted to the age of the children. The load intensity within ADP was moderate to vigorous. The exercise was performed in small groups, 3-4 students, so the rest time between repetitions was a few seconds (the time needed for the other members of the group to complete their performance), while the rest time between the exercises was 30 seconds. Balls (for football and basketball) were also used in the exercises, so certain movements, except those ones without the ball, were performed both with the ball as an aggravating parameter. The presence of a semi-active opponent (students took turns in that role) was also used, which to a certain extant also made the movement difficult. Mobile games were also in use, and they were conducted every other lesson and covered a third of the time of ADP (about 5 minutes).

Table 1 shows the exercises and mobile games used in the ADP. For each lesson, the contents are combined (with and without ball) in order to avoid monotony in the exercise (not all exercises were used in every lesson).

Statistical analysis

Descriptive parameters (Mean ± St.Dev) were calculated for all variables. Two-tailed independent t-test was used to analyze differences in agility between the ADP and the CON and the change in the performance from pre- to posttests between groups. Two-tailed paired t-test was used to analyze changes in agility performance between pre- and posttests within both groups. The statistical package SPSS v was used for data processing 22.0 (IBM SPSS Statistics). Statistical sig-

Table 1. Content of ADP

Indicator	Number of repetitions
running forward	4×5m (with and without football or basketball)
running backward	4×5m
lateral running – right	4×5m (with and without ball)
lateral running – left	4×5m (with and without ball)
running forward-backward	4×5m (5m forward, turn around cone and 5m backward)
quadrilateral	2 repetitions – quadrilateral with 5m sides (running forward, lateral right, running backward, lateral left)
lateral meandering (left and right)	4×5m
figure 8	4 repetitions – 3 cones with 1.5m distance between them (with and without ball)
running in letters	2 repetitions – writing letters by running (3-4 letters by lesson) (with and without ball)
explosive running with change of direction	4 repetitions – at a distance of 5-7m (with and without ball)
various forms of movement on football ladders (forward, lateral, jumps backward and forward, side steps inside and outside the ladder, running with high knees)	2 repetitions of every form of movement
Mobile games (some of those that were used) – (according to Skitnevskiy et al., 2020; Milenković, 2021).	
"Night and day"	The playground's middle area is crossed by two parallel lines with 1-1.5m distance from each other. The students are divided into two teams ("Nigth" and "Day") standing in two rows facing each other. The teacher who is aside the playground exclaims either a "Day" or "Night" and students of the appropriate team should strive to reach the outside boundary of own line, whereas the opposite team should chase and catch them within the field limits.
"Entrapment"	The students are divided into five groups. Four groups are standing on the corners of the field in a column, while the fifth group is standing in the center of the field. At the given sign, all students from four outer groups run to the right toward the place of the next group. The center group is trying to catch as many students as possible before they reach the next corner. The one who is caught joins the catchers.
"Delta"	Two columns are standing behind the starting line. At a distance of 5 m from the starting line, the second line is marked. At a given sign, first student in the column runs to the second line, touches it with his/her hand, then runs to the starting line, steps on it with his/her foot, runs again to the set line, steps on it with both feet, comes back and has to touch the next student who starts running. The winner is the team that completes the task first.
"Pull attempt" game	Students of two teams receive the same ordinal numbers. Everybody should run in pairs along the run-way. At some point of movement, the teacher shouts out the ordinal number. Those students having this number should reach the head of the column and be the leading runners. The run should proceed till the new signal. The winning team is the one having the most leaders in it.

nificance was established at the level of $p \leq 0.05$. The results will be shown separately for boys and girls.

Results

The students successfully completed the experimental treatment without any injuries. Both groups of respondents had a high attendance rate (over 95%). On pre-experimental testing, there were no significant differences between groups in any of the variables, including the Zig-zag test, the Illinois agility run test, the Agility T test, the Balsom agility test, and the Arrowhead agility test.

ADP group (both for boys and girls) showed significant pre-posttest change in Zig-zag test, Illinois Agility Run test, Agility T test and Arrowhead Agility test ($p \leq 0.05$), but not in Balsom Agility test ($p > 0.05$). CON group (both for boys and girls) showed significant pre-posttest change in performance in Zig-zag test and Agility T test ($p \leq 0.05$) (Table 3, 4).

Training responses were different between ADP and CON group. Compared with the CON, the ADP group (both for boys and girls) showed significantly better performances ($p \leq 0.05$) in Zig-zag test, Illinois Agility Run test, Agility T test and Arrowhead Agility test after the training period, but also not in Balsom agility test ($p > 0.05$) (Table 5, 6).

Table 2. Group characteristics (Mean±St.Dev)

Characteristics (total of 107)	ADP group (N=55)	CON group (N=52)
Age (y)	11.5±0.4	11.4±0.5
Body height (cm)	151.6±7.1	152.3±6.9
Body mass (kg)	43.8±8.3	43.3±8.5
BMI (kg/m^2)	18.9±3.5	19.2±3.7

ADP – agility development program; CON – control; BMI – Body mass index.

Table 3. Two-tailed paired t-test (pre-posttest results) for both groups, boys

Group	Agility tests	Mean (±SD)	N	t	df	Sig. (2-tailed)
ADP boys	Zig-zag	8.94±0.27				
	Zig-zag (retest)	8.01±0.35	30	21.22	29	.000*
	Illinois	20.07±0.65				
	Illinois (retest)	19.18±0.59	30	16.73	29	.000*
	"T" test	13.04±0.7				
	"T" test (retest)	12.36±0.79	30	7.04	29	.000*
	Balsom	20.58±1.1				
	Balsom (retest)	20.57±1.09	30	1.09	29	.284
	Arrowhead	19.86±0.68				
	Arrowhead (retest)	19.21±0.6	30	9.97	29	.000*
CON boys	Zig-zag	8.91±0.35				
	Zig-zag (retest)	8.62±0.48	25	6.04	24	.000*
	Illinois	20.28±0.64				
	Illinois (retest)	20.25±0.66	25	1.36	24	.185
	"T" test	13.12±0.65				
	"T" test (retest)	12.81±0.69	25	4.35	24	.000*
	Balsom	20.51±1.08				
	Balsom (retest)	20.54±1.16	25	-0.64	24	.531
	Arrowhead	19.86±0.75				
	Arrowhead (retest)	19.84±0.7	25	0.4	24	.692

*Statistical significance is at the level of $p \leq 0.05$

Table 4. Two-tailed paired t-test (pre-posttest results) for both groups, girls

Group	Agility tests	Mean (±SD)	N	t	df	Sig. (2-tailed)
ADP girls	Zig-zag	9.57±0.36				
	Zig-zag (retest)	8.76±0.58	25	14.04	24	.000*
	Illinois	20.72±0.48				
	Illinois (retest)	19.78±0.55	25	18.53	24	.000*
	"T" test	13.65±0.58				
	"T" test (retest)	12.94±0.64	25	11.93	24	.000*
	Balsom	21.63±0.56				
	Balsom (retest)	21.62±0.56	25	1.9	24	.069
	Arrowhead	20.67±0.83				
	Arrowhead (retest)	19.91±0.84	25	11.33	24	.000*
CON girls	Zig-zag	9.78±0.27				
	Zig-zag (retest)	9.36±0.16	27	9.58	26	.000*
	Illinois	20.86±0.6				
	Illinois (retest)	20.83±0.66	27	1.1	26	.280
	"T" test	13.64±0.79				
	"T" test (retest)	13.33±0.71	27	6.27	26	.000*
	Balsom	21.75±0.39				
	Balsom (retest)	21.72±0.55	27	0.47	26	.644
	Arrowhead	20.43±0.96				
	Arrowhead (retest)	20.53±0.93	27	-1.76	26	.091

*Statistical significance is at the level of $p \leq 0.05$

Table 5. Two-tailed independent t-test (posttest results between groups), boys

Agility tests	Boys	Mean (±SD)	N	t	df	Sig. (2-tailed)
Zig-zag	ADP	8.01±0.35	30			
	CON	8.62±0.48	25	-5.42	53	.000*
Illinois	ADP	19.18±0.59	30			
	CON	20.25±0.66	25	-6.35	53	.000*
"T" test	ADP	12.36±0.79	30			
	CON	12.81±0.69	25	-2.22	53	.030*
Balsom	ADP	20.57±1.09	30			
	CON	20.54±1.16	25	0.11	53	.915
Arrowhead	ADP	19.21±0.6	30			
	CON	19.84±0.7	25	-3.65	53	.001*

*Statistical significance is at the level of $p \leq 0.05$

Discussion

The aim of this research was to determine the effects of the eight-week agility development program (ADP) which was conducted as a part of the main part of the physical education class with the fifth grade elementary school students. The program, which was adapted to the children of this age, proved to be suitable, safe and effective for working on the direct development of agility and the indirect development of other abilities which agility is significantly

Table 6. Two-tailed independent t-test (posttest results between groups), girls

Agility tests	Girls	Mean (±SD)	N	t	df	Sig. (2-tailed)
Zig-zag	ADP	8.76±0.58	25			
	CON	9.36±0.16	27	-5.2	50	.000*
Illinois	ADP	19.78±0.55	25			
	CON	20.83±0.66	27	-6.17	50	.000*
"T" test	ADP	12.94±0.64	25			
	CON	13.33±0.71	27	-2.1	50	.041*
Balsom	ADP	21.62±0.56	25			
	CON	21.72±0.55	27	-0.64	50	.526
Arrowhead	ADP	19.91±0.84	25			
	CON	20.53±0.93	27	-2.52	50	.015*

*Statistical significance is at the level of $p \leq 0.05$

correlated with. The children found the program to be very entertaining and at the same time it provided a sufficient amount of physical activity which led to improved physical performance.

Other researches also indicate an improvement in the level of agility and general physical performance in the form of speed, coordination of skills during lateral movements (Sopa & Pomohaci, 2016). Yanci et al. (2013), after implementing various variants of the contextual interference program, found that with elementary school students, after three weeks of work, the progress in the level of agility was recorded. This proves that in working with children, it is much more effective to implement motor learning programs through mastering multiple skills or skills variations, than to use unilateral programs to improve children's health and development (Shea & Morgan, 1979; Faigenbaum et al., 2015).

Interesting and diverse content and the optimal amount of time dedicated to physical activity in working with children in physical education classes is one of the essential elements of success in implementing planned programs and improving physical performance and student skill levels (Hills, Dengel & Lubans, 2015). In this research as well one of the main reasons for improving the levels of physical performance in which agility dominates is precisely the interestingness and variety of content to which children react positively. The monotonous content of physical activity negatively affects the concentration of children and as a consequence there is a loss of interest in activities (Rokhayati et al., 2017). In younger children, the direction, maintenance, stability and stability of attention at the optimal level for work last shorter than in older children (Rueda et al., 2005). As a child grows, attention control also improves and increases the duration of attention, while reducing the ease with which attention can be distracted. In this regard, teaching content must be enjoyable, positive, with a significant impact of exercise on the body, with a good foundation in practical knowledge and with a comprehensive teaching strategy by the teacher who plays an important role in motivating students (Maldonado et al., 2019).

The agility development program also influences the improvement of speed and explosiveness due to the great association with this physical performance (Lockie et al., 2014; Dawes, 2019; Herridge, Turner & Bishop, 2020). The results of agility tests in this study, which were significantly better in the final testing in most tests, indirectly indicate an improvement in movement speed and reaction speed, as well as explosiveness of movement. Since time is measured in agility tests, it is clear that the students achieved shorter time by performing the tests after the experimental treatment, and at the same time, they were faster and more explosive. This interconnection between the components of physical abilities is also confirmed by previous researches (Pettersen & Mathisen, 2012; Moradi & Esmaeilzadeh, 2015; Coetzee, 2016; Szabo, Neagu & Sopa, 2020). For example, elementary school students who participated in a six-week program consisting of short explosive activities were found to have a positive effect on performance in speed and agility (Pettersen & Mathisen, 2012) or in a Coetzee study (2016) that found a significant correlation between agility and sprinting speed in children aged 9 and 10, but also with strength and balance. Szabo, Neagu & Sopa (2020) claim that a specific program for the development of combined motor skills significantly affects speed and agility, which also indicates their interconnectedness.

Various specialized programs within physical education that are conducted with school children, such as programs for the development of agility in this research, contribute to even greater and more efficient physical engagement of children. There is a need for greater physical activity in children and adolescents in order to improve physical ability by increasing muscle strength, because the research indicates that, in addition to risk factors expressed through body mass index and blood pressure, low levels of muscle strength in childhood and adolescence are associated with health problems and even premature death (Ortega et al., 2012). Low level of physical activity and cardiorespiratory abilities are strongly associated with insufficient competence in basic motor skills in children and adolescents (Hardy et al., 2012). Therefore, it is necessary to work as much as possible on the physical activation of children through various physical education programs and as early as possible, because after puberty the level of activity decreases (Whitt-Glover et al., 2009), so it is important to establish the positive effects of physical exercise on human organism throughout his life as well.

The limitations of this research can be reflected in the length of the experimental treatment itself and the impossibility of longer-term adaptation of the student's organism to training impulses. In order to obtain more comprehensive results of the effects of the agility development program, a sample that includes a larger number of respondents of different ages and from different areas is required. Moreover the program can be extended to other parameters of the SAQ training program, speed and explosiveness as well.

Conclusion

The results of this study showed that eight-week ADP (twice a week for 15 minutes within the main part of the physical education class) contributed to a significant improvement in the level of agility. The results of most of the tests used showed a significant effect of experimental work on the tested ability of the fifth grade elementary school students. When observing the ADP group (both for boys and girls), only one agility test (Balsom agility test) did not show a statistically significant within-group change in performance, while the progress in the results of other tests was at the level of $p \leq 0.05$. In the CON group (both for boys and girls), a

positive within-group change in performance was observed in the Zig-zag test and the Agility T test at the level of $p \leq 0.05$. At the end, the training effect of a specially designed agility development program affected between-groups change in performance (both for boys and girls) after the program was completed all but one test (Balsom agility test). Thus, it can be said that the agility development program was successful. Both groups of students (ADP and CON) had the same traditional physical education classes with the same teacher, but the additional program in the main part of the ADP group classes contributed to the adaptation of students to the specific training requirements to which they were exposed, thus the goal of the research that was originally set was fulfilled because the positive effect of the 8-week agility development program (ADP) on improving agility was determined.

Practical applications

Thanks to this research, the students had the opportunity to improve their level of agility through different ways of moving and manipulating objects, to further develop the technique of movement in changing conditions and to influence the raising of competence levels in basic motor skills. They were also introduced to a large number of games that represent an effective method and means for the development of children's physical performance, specifically agility (Yanci et al., 2014). Given the fact that agility is an ability that correlates with many other abilities (Sekulić et al., 2013), ADP can be useful as one of the elements for the development of general physical preparation of elementary school children as a basis for participation in games, sports and other physical activities. The results obtained in this research indicate that right this and such a program could be a sustainable model of work in school physical education and that together with the professional guidance of physical education teachers can contribute to improving physical performance and various skills needed for proper development of children. Although short-lasting, this particular experimental treatment can also be used to design and implement other physical education programs with longer-term effects on students' physical and health status.

Conflict of interest

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References

Milenković, D. (2021). *Fizičko vaspitanje i sport (Physical education and sport)*. Belgrade: Faculty of Sport, University Union – Nikola Tesla.

Gadžić, A. (2019). *Teorija i metodika fizičkog i zdravstvenog vaspitanja (Theory and methodics of physical and health education)*. Belgrade: Singidunum University.

Faigenbaum, A.D., Bush, J.A., McLoone, R.P., Kreckel, M.C., Farrell, A., Ratamess, N.A., & Kang, J. (2015). Benefits of strength and skillbased training during primary school physical education. *Journal of Strength and Conditionig Research, 29*(5), 1255-1262. https://doi.org/10.1519/JSC.0000000000000812

Behringer, M., Vom Heede, A., Matthews, M., & Mester, J. (2011). Effects of strength training on motor performance skills in children and adolescents: A meta-analysis. *Pediatric Exercise Science, 23*(2), 186-206. https://doi.org/10.1123/pes.23.2.186

Katzmarzyk, P.T., Barreira, T.V., Broyles, S.T., Champagne, C.M., Chaput, J-P., Fogelholm, M., Hu, G., Johnson, W.D., Kuriyan, R., Kurpad, A., Lambert, E.V., Maher, C., Maia, J., Matsudo, V., Olds, T., Onywera, V., Sarmiento, O.L., Standage, M., Tremblay, M.S., Tudor-Locke, C., Zhao, P., & Church, T.S. (2015). Relationship between lifestyle behaviors and obesity in children ages 9-11: Results from a 12-country study. *Obesity, 23*(8), 1696-1702. https://doi.org/10.1002/oby.21152

Brown, T., Moore, T.H.M., Hooper, L., Gao, Y., Zayegh, A., Ijaz, S., Elwenspoek, M., Foxen, S.C., Magee, L., O'Malley, C., Waters, E., & Summerbell, C.D. (2019). Interventions for preventing obesity in children. *Cochrane Database of Systematic Reviews, 7*. https://doi.org/10.1002/14651858.CD001871.pub4

Aguilar-Cordero, M.J., Rodríguez-Blanque, R., Leon-Ríos, X., Ruiz, M.E., García, I.G., & Sánchez-López, A.M. (2020). Influence of Physical Activity on Blood Pressure in Children With Overweight/Obesity: A Randomized Clinical Trial. *American Journal of Hypertension, 33*(2), 131-136. https://doi.org/10.1093/ajh/hpz174

Stavridou, A., Kapsali, E., Panagouli, E., Thirios, A., Polychronis, K., Bacopoulou, F., Psaltopoulou, T., Tsolia, M., Sergentanis, T.N., & Tsitsika, A. (2021). Obesity in Children and Adolescents during COVID-19 Pandemic. *Children, 8*(2), 135. https://doi.org/10.3390/children8020135

Cvetković, N., Stojanović, E., Stojiljković, N., Nikolić, D., Scanlan, A.T., & Milanović, Z. (2018). Exercise training in overweight and obese children: Recreational football and high-intensity interval training provide similar benefits to physical fitness. *Scandinavian Journal of Medicine & Science in Sports, 28*(S1), 18-32. https://doi.org/10.1111/sms.13241

Steene-Johannessen, J., Hansen, B.H., & Dalene, K.E. et al. (2020). Variations in accelerometry measured physical activity and sedentary time across Europe – harmonized analyses of 47,497 children and adolescents. Internationl *Journal of Behavioral Nutrition and Physical Activity, 17*(38). https://doi.org/10.1186/s12966-020-00930-x

Sekulić, D., Spasić, M., Mirkov, D., Cavar, M., & Sattler, T. (2013). Gender-specific influences of balance, speed, and power on agility performance. *Journal of Strength and Conditioning Research, 27*(3), 802-811. https://doi.org/10.1519/JSC.0b013e31825c2cb0

Lemmink, K. A., Elferink-Gemser, M. T., & Visscher, C. (2004). Evaluation of the reliability of two field hockey specific sprint and dribble tests in young field hockey players. *British Journal of Sports Medicine,* 38, 138-142. https://doi.org/10.1136/bjsm.2002.001446

Bompa, T. (2006). *Periodization: Theory and methodology of training.* Champaign, IL: Human Kinetics.

Young, W.B., James, R., & Montgomery, I. (2002). Is Muscle Power Related to Running Speed with Changes of Direction? *Journal of Sports Medicine and Physical Fitness, 43*(3), 282-288. https://pubmed.ncbi.nlm.nih.gov/12094116

Young, W., & Farrow, D. (2006). A review of agility: practical applications for strength and conditioning. *Strength and Conditioning Journal, 28*(5), 24-29. https://www.proquest.com/openview/3791519d35b1765524168d2745fa843c/1?pq-origsite=gscholar&cbl=44253

Gabbett, T.J., Kelly, J.N., & Sheppard, J.M. (2008). Speed, change of direction speed, and reactive agility of rugby league players. *Journal of Strength and Conditioning Research, 22*(1), 174-181. https://doi.org/10.1519/JSC.0b013e31815ef700

Sheppard, J.M., Young, W.B., Doyle, T.L., Sheppard, T.A., & Newton, R.U. (2006). An evaluation of a new test of reactive agility and its relationship to sprint speed and change of direction speed. *Journal of Science and Medicine in Sport, 9*(4), 342-349. https://doi.org/10.1016/j.jsams.2006.05.019

Köklü, Y., Alemdaroğlu, U., Özkan, A., Koz, M., & Ersöz, G. (2015). The relationship between sprint ability, agility and vertical jump performance in young soccer players. *Science & Sports, 30*(1), e1-e5. https://doi.org/10.1016/j.scispo.2013.04.006

Brown, L., & Ferrigno, V. (eds) (2005). *Training for speed agility and quickness.* 2nd edition. Champaign, IL: Human Kinetics.

Acar, H., & Eler, N. (2019). The Effect of Balance Exercises on Speed and Agility in Physical Education Lessons. *Universal Journal of Educational Research, 7*(1), 74-79. https://doi.org/10.13189/ujer.2019.070110

Sopa, I.S., & Pomohaci, M. (2016). Study regarding the development of agility skills of students aged between 10 and 12 years old. *Timişoara Physical Education and Rehabilitation Journal, 9*(17), 7-16. https://doi.org/10.1515/tperj-2016-0009

Plisk, S.S. (2000). *Speed, agility and speed endurance development.* In T.R. Beachle & R.W. Earle (Eds.), Essential of Strength Training and Conditioning, Champaign, IL: Human Kinetics.

Verstegen, M., & Marcello, B. (2001). *Agility and coordination.* In B. Forran (ed), High performance sports conditioning (pp 139-165). Champaign, IL: Human Kinetics.

Haga, M. (2008) The relationship between physical fitness and motor competence in children. *Child: Care, Health and Development, 34*(3), 329-334. https://doi.org/10.1111/j.1365-2214.2008.00814.x

Aribowo, D.S., Hidayah, T., & Rumini, R. (2019). The Effectiveness of Indonesian Traditional Games and Agility on Student's Gross Motor Skills in Elementary School Hj. Isriati Baiturrahman 2 Semarang. *Journal of Physical Education and Sports, 8*(3), 281-287. https://doi.org/10.15294/jpes.v8i3.31273

Bijelić, S., & Simović, S. (2005). *Trenažna tehnologija u radu sa mladim sportistima (Training technology in working with young athletes).* Banja Luka: Sekretarijat za sport i omladinu u Vladi Republike Srpske.

Topend Sports. *The complete FITNESS TEST* list. https://www.topendsports.com/testing/tests/index.htm.

World Medical Association Declaration of Helsinki (2013). *Ethical Principles for Medical Research Involving Human Subjects,* 64th WMA General Assembly, Fortaleza, Brazil, October 2013. Retrieved November 25, 2020 from the World Wide Web: http://www.wma.net/en/30publications/10policies/b3/index.html

Kutlu, M., & Doğan, Ö. (2018). Test-Retest Reliability and Validity of Three Different Agility Tests for Various Team Sports in Young Male Athletes. *Central European Journal of Sport Sciences and Medicine, 22*(2), 33-38. https://doi.org/10.18276/cej.2018.2-04

Kutlu, M., Yapici, H., & Yilmaz, A. (2017). Reliability and Validity of a New Test of Agility and Skill for Female Amateur Soccer Players. *Journal of Human Kinetics,* 56, 219-227. https://doi.org/10.1515/hukin-2017-0039

Hachana, Y., Chaabène, H., Ben Rajeb, G., Khlifa, R., Aouadi, R., Chamari, K., & Gabbett, T.J. (2014). Validity and Reliability of New Agility Test among Elite and Subelite under 14-Soccer Players. *PLOS One, 9*(4), e95773. https://doi.org/10.1371/journal.pone.0095773

Pauole, K., Madole, K., Garhammer, J., Lacourse, M., & Rozenek, R. (2000). Reliability and Validity of the T-Test as a Measure of Agility, Leg Power, and Leg Speed in College-Aged Men and Women. *Journal of Strength and Conditioning Research, 14*(4), 443-450. https://journals.lww.com/nsca-jscr/Abstract/2000/11000/Reliability_and_Validity_of_the_T_Test_as_a.12.aspx

Fessi, M.S., Makni, E., Jamni, M., Elloumi, M., Chamari, K., Nabli, M.A., Padulo, J., & Moalla, WE. (2016). Reliability and criterion-related validity of a new repeated agility test. *Biology of Sport, 33*(2), 159-164. https://doi.org/10.5604/20831862.1198635

Wrigley, J.M. (2016). *A study to validate the use of; The Modified Balsom Run as an accurate measurement of repeated sprint ability in U18 elite soccer players.* Bsc dissertation. Leeds: Leeds Beckett University, Carnegie Faculty.

Lockie, R.G., & Jalilvand, F. (2017). Reliability and criterion validity of the arrowhead change-of-direction speed test for soccer. *Facta Universitatis Series: Physical Education and Sport, 15*(1), 139-151. https://doi.org/10.22190/FUPES1701139L

Rago, V., Brito, J., Figueiredo, P., Ermidis, G., Barreira, D., & Rebelo, A. (2020). The Arrowhead Agility Test: Reliability, Minimum Detectable Change, and Practical Applications in Soccer Players. *Journal of Strength and Conditioning Research, 34*(2). 483-494. https://doi.org/10.1519/JSC.0000000000002987

Skitnevskiy, V.L., Krasilnikova, Y.S., Grigoryeva, E.L., Sedov, I.A., Balashova, V.F., & Smirnov, S.A. (2020). Deveoping Agility: Through Physical Gaming Activity With Adolescent Kids During Lessons of Physical Training. *Revista Científica de la Universidad de Cienfuegos, 12*(4), 38-44. https://rus.ucf.edu.cu/index.php/rus/article/view/1610

Yanci, J., Cámara, J., Reina, R., & Los Arcos, A., (2014). *Effects of traditional games played in physical education classes with elementary school students.* In R. Torrado (ed), Handbook of Physical Education Research: Role of School Programs, Children's Attitudes and Health Implications. Hauppauge, NY: Nova Science Publishers, Inc. https://www.researchgate.net/publication/260417329

Shea, J.B., & Morgan, R.L. (1979). Contextual interference effects on the acquisition, retention, and transfer of a motor skill. *Journal of Experimental Psychology: Human Learning and Memory, 5*(2), 179-187. https://doi.org/10.1037/0278-7393.5.2.179

Hills, A.P., Dengel, D.R., & Lubans, D.R. (2015). Supporting Public Health Priorities: Recommendations for Physical Education and Physical Activity Promotion in Schools. *Progress in Cardiovascular Diseases, 57*(4), 368-374. https://doi.org/10.1016/j.pcad.2014.09.010

Rokhayati, A., Nur, L., Elan, & Gandana, G. (2017). Tactical Approach to Increase Motivation for Learning Students on Physical Education Teaching in Primary Schools. *IOP Conference Series: Materials Science and Engineering,* 180. https://doi.org/10.1088/1757-899X/180/1/012259

Rueda, M.R., Rothbart, M.K., McCandliss, B.D., Saccomanno, L., & Posner, M.I. (2005). Training, maturation, and genetic influences on the development of executive attention. *PNAS, 102*(41), 14931-14936. https://doi.org/10.1073/pnas.0506897102

Maldonado, E., Zamarripa, J., Ruiz-Juan, F., Pacheco, R., & Delgado, M. (2019). Teacher Autonomy Support in Physical Education Classes as a Predictor of Motivation and Concentration in Mexican Students. *Frontiers in Psychology,* 10, 2834. https://doi.org/10.3389/fpsyg.2019.02834

Lockie, R.G., Schultz, A.B., Callaghan, S.J., & Jeffriess, M.D. (2014). The effects of traditional and enforced stopping

speed and agility training on multidirectional speed and athletic function. *Journal of Strength and Conditioning Research, 28*(6), 1538-1551. https://doi.org/10.1519/JSC.0000000000000309

Dawes, J. (2019). *Developing Agility and Quickness.* Champaign, IL: Human Kinetics.

Herridge, R., Turner, A., & Bishop, C. (2020). Monitoring changes in power, speed, agility, and endurance in elite cricketers during the off-season period. *Journal of Strength and Conditioning Research, 34*(8), 2285-2293. https://doi.org/10.1519/JSC.0000000000002077

Pettersen, S.A., & Mathisen, G.E. (2012). Effect of short burst activities on sprint and agility performance in 11- to 12-year-old boys. *Journal of Strength and Conditioning Research, 26*(4), 1033-1038. https://doi.org/10.1519/JSC.0b013e31822e58c8

Moradi, A., & Esmaeilzadeh, S. (2015). Association between reaction time, speed and agility in schoolboys. *Sport Sciences for Health,* 11, 251-256. https://doi.org/10.1007/s11332-015-0230-4

Coetzee, D. (2016). Strength, Running Speed, Agility and Balance Profiles of 9- to 10-year-old Learners: NW-CHILD Study. *South African Journal for Research in Sport, Physical Education and Recreation, 38*(1), 13-30. https://hdl.handle.net/10520/EJC186990

Szabo, D.A., Neagu, N., & Sopa, I.S. (2020). Research regarding the development and evaluation of agility (balance, coordination and speed) in children aged 9-10 years. *Health, Sports & Rehabilitation Medicine, 21*(1), 33-40. https://doi.org/10.26659/pm3.2020.21.1.33

Ortega, F., Silventoinen, K., Tynelius, P., & Rasmussen, F. (2012). Muscular strength in male adolescents and premature death: Cohort study of one million participants. *The BMJ,* 345, e7279. https://doi.org/10.1136/bmj.e7279

Hardy, L.L., Reinten-Reynolds, T., Espinel, P., Zask, A., & Okely, A.D. (2012). Prevalence and correlates of low fundamental movement skill competency in children. *Pediatrics, 130*(2), e390-e398. https://doi.org/10.1542/peds.2012-0345

Whitt-Glover, M.C., Taylor, W.C., Floyd, M.F., Yore, M.M., Yancey, A.K., & Matthews, C.E. (2009). Disparities in physical activity and sedentary behaviors among US children and adolescents: Prevalence, correlates, and intervention implications. *Journal of Public Health Policy, 30*(suppl 1), S309-S334. https://doi.org/10.1057/jphp.2008.46

ЕФЕКТ ВОСЬМИТИЖНЕВОЇ ПРОГРАМИ РОЗВИТКУ СПРИТНОСТІ В УЧНІВ ПОЧАТКОВОЇ ШКОЛИ

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 8 с., 6 табл., 53 джерел.

Мета дослідження – визначити ефект восьмитижневої програми розвитку спритності (ПРС) в учнів початкової школи.

Матеріали та методи. У тестуванні брали участь 107 учнів п'ятого класу початкової школи з чотирьох класів, випадковим чином визначених як група програми розвитку спритності (ПРС) (n = 55) та контрольна (К) група (n = 52). Учні мали два уроки фізкультури на тиждень, всього 16 занять за вісім тижнів. ПРС тривалістю 15 хвилин проводилася в рамках основної частини уроку фізкультури. Обидві групи відвідували уроки фізкультури, за винятком того, що контрольна група мала заняття без спеціальної програми розвитку спритності. Двосторонній незалежний t-тест використовувався для аналізу відмінностей у спритності між ПРС і К і зміни продуктивності до- та післятестами між групами. Двосторонній парний t-тест був використаний для аналізу змін у показниках спритності між до- та післятестами в обох групах.

Результати. У порівнянні з контрольною групою група ПРС показала значно кращі результати ($p \leq 0,05$) у тесті зигзаг, тесті спритності Іллінойсу, тесті спритності Т та тесті на спритність стрілка після періоду тренування, але не в тесті на спритність Бальсома ($p > 0,05$).

Висновки. Визначено позитивний вплив 8-тижневої програми розвитку спритності (ADP) на поліпшення рівня розвитку координації рухів. Програма розвитку спритності може сприяти підвищенню фізичної працездатності та формуванню різноманітних навичок, необхідних для розвитку дітей.

Ключові слова: фізична культура, діти, тренування спритності, рухові здібності.

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ІНСТРУКЦІЇ ДЛЯ РЕЦЕНЗЕНТІВ

Цей журнал є рецензованим. Оригінальні наукові статті, повідомлення та огляди надсилаються для розгляду одному з рецензентів. Рецензування відбувається за подвійною сліпою схемою. Статті, які мають позитивні оцінки приймаються до публікації. Редакція журналу залишає за собою право внести зміни до тексту, щоб відповідати стандартам стилю журналу та мови.

Головний редактор журналу визначає відповідність статті профілю журналу, вимогам до оформлення і направляє її на рецензування фахівцю, що має найбільш близьку до теми статті наукову спеціалізацію. Рецензування проходить за подвійною сліпою схемою.

У кожній статті у процесі рецензування завжди розглядаються:

- етичні аспекти;
- оригінальність твору;
- важливість інформації;
- чіткість та зрозумілість тексту;
- доцільність використання методів дослідження;
- інтерпретація результатів;
- обґрунтованість висновків.

Типовий період, необхідний для проведення рецензування складає 4 тижні.

Етичні принципи у діяльності рецензента

Рецензент здійснює неупереджене фахове рецензування поданої до розгляду статті на основі таких принципів:

- рецензент повинен поважати інтелектуальну власність авторів, і розглядати рукопис статті, що надійшов на рецензування, як конфіденційний, який не можна передавати для ознайомлення або обговорення третім особам, які не мають на це повноважень від редакції;
- рецензент зобов'язаний давати об'єктивну оцінку викладеним результатам дослідження, персональна критика автора неприпустима;
- у разі конфлікту інтересів з автором, слід повідомити про це редактора з проханням виключити його з процесу рецензування даної статті.

Політика щодо плагіату

Редакція журналу вважає неприйнятним наявність плагіату в статтях (оприлюднення у письмовій або електронній формі наукових результатів, отриманих та оприлюднених іншими особами, як результатів власного дослідження та/або відтворення опублікованих текстів інших авторів без відповідного посилання).

У статтях не допускається:

- копіювання та оприлюднення виконаної іншим автором роботи як своєї;
- дослівне копіювання фрагментів тексту (від фрази до набору речень) без належного оформлення цитування;
- внесення незначних правок у скопійований матеріал (переформулювання речень, зміна порядку слів в них тощо) та без належного оформлення цитування;
- переказ своїми словами чужих думок, ідей або тексту без належного оформлення посилання на джерело.

Обов'язковим є посилання на власні, раніше опубліковані роботи.

Редакція відхиляє поданий рукопис, якщо він містить запозичення з інших публікацій без належного цитування, та може скасувати публікацію за скаргою в плагіаті.

Як підготувати рецензію?

Попередній огляд

Перш ніж прийняти або відхилити запрошення на рецензування, розгляньте такі питання:

Чи відповідає стаття вашій спеціалізації? Приймайте запрошення, якщо ви впевнені, що можете надати якісний огляд.

Чи є у вас конфлікт інтересів? Дайте відповідь на це питання.

Чи є у вас час? Рецензування може вимагати багато часу – перш ніж приймати запрошення, переконайтеся, що ви можете виконати роботу до вказаного строку.

Дайте відповідь на запрошення, як тільки ви зможете. Затримка відповіді сповільнює процес розгляду матеріалу. Якщо ви відхилите запрошення, за можливості, надайте пропозиції альтернативних рецензентів.

Якщо ви приймаєте запрошення, то ви повинні розглядати матеріали як конфіденційні документи. Це означає, що ви не можете поділитися ними з ким-небудь без попереднього дозволу редактора. Оскільки експертний огляд є конфіденційним, ви також не повинні передавати інформацію про рецензію будь-кому без дозволу редакторів та авторів.

По-перше, прочитайте статтю, а потім зробіть перерву. Розгляньте статтю з власної точки зору. Переконайтеся, що ви знаєте критерії оцінки статті, запропоновані журналом.

Огляд

Ваша рецензія допоможе редакторові вирішити, чи слід публікувати статтю. Важливою є ваша загальна думка та висновки про статтю. Ваші коментарі повинні бути доброзичливими та конструктивними, а також не містити жодних особистих зауважень чи особистих даних, включаючи ваше ім'я.

Важливо надати інформацію про будь-які наявні недоліки. Ви повинні пояснити ваше судження, щоб як редактори, так і автори, могли повною мірою зрозуміти ваші коментарі.

Контрольний список

Оцініть такі аспекти статті: (якщо відповідь «Ні», будь ласка, за можливості, запропонуйте покращення в полі «Інформація для авторів»)

- Чи заголовок точно відображає зміст тексту?
- Чи чітко зазначено мету?
- Чи суттєвий внесок у розробку зазначеної проблеми робиться цією статтею?
- Чи розкриває стаття мету дослідження?
- Чи логічно викладений матеріал статті?
- Чи висвітлена в анотації суть статті, анотація є інформативною та лаконічною?
- Чи висновки автора адекватні експериментальному матеріалу?

Надайте конкретні коментарі та пропозиції, зокрема, щодо оформлення, назви, опису, вступу, гіпотези та/або предмету дослідження, матеріалів і методів, статистичної обробки матеріалів, результатів, обговорення, висновків, мови та посилань.

Якщо ви вбачаєте прояви академічної недоброчесної, обговоріть свої підозри з редактором, надайте якомога докладнішу інформацію.

Ваша рекомендація

Коли ви даєте рекомендацію, то обираєте одну з категорій, які використовуються для класифікації статті:

- прийняти подання;
- необхідні виправлення;
- необхідне додаткове рецензування;
- до іншого видання;
- відхилити подання.

Остаточне рішення

Головний редактор вирішує, чи прийняти чи відхилити статтю. Редактор, перш ніж прийняти рішення, зважить всі погляди та може зажадати третю думку або попросити автора переглянути документ. Видавнича система надає користувачам повідомлення про остаточне рішення.

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