



ORIGINAL SCIENTIFIC ARTICLE

INTENSIFICATION OF BACK MUSCLE STRENGTH TESTING IN PHYSICAL EDUCATION OF STUDENTS BY APPLYING INFORMATION AND COMMUNICATION TECHNOLOGIES

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Abstract

The purpose of this study is the experimental substantiation of the implementation of information and communication technologies to test the control of back muscle strength in the process of physical education of students.

Materials and methods. General scientific methods were used to solve the research problems: analysis, synthesis, generalization, induction and systematization, technical modeling, pedagogical experiment, pedagogical testing, and mathematical methods. The study involved 240 students aged 17 to 18 at the beginning of the study.

Results. An electronic device for determining the strength of the muscles of the back was developed and tested, the readings of which allow the user to get clear current information on the panel of a personal computer. The device was built on a combination of modern electronic technologies and software. For the purposes of the experimental substantiation of the developed back muscle strength control device, a correlation analysis was used to empirically investigate the authenticity degree of the tests used to control back muscle strength. According to the results of the reliability of the tests of back muscle strength control tests, the results of which were recorded using a dynamometer, those are between low and medium. The recording of the back muscle strength test results with the developed device ensured the achievement of a high level of test authenticity.

Conclusions. The result of the research study aimed at solving the problematic aspects of test control was to ensure the appropriate degree of authenticity of the tests used to control back muscle strength. The recording of the back muscle strength test results with the developed device ensured the achievement of a high level of test authenticity.

Keywords: testing, control, physical education, student, back muscle strength, device, information and communication technologies.

Introduction

Problem statement. The current stage of reorganization of the system of physical education in universities as an important part of social policy is characterized by active evolutionary changes. Effective physical education of young people is historically one of the first significant pedagogical problems, and, at the same time, the center of the innovative pedagogical movement (Anikieiev, 2015). The urgency of finding ways to improve the effectiveness of physical educa-

tion for students is growing significantly in connection with the reorganization of higher education in accordance with European standards. The problem is important for the health of the nation, especially young people.

Promising, in connection with the above, is the use of innovative methods based on information and communication technologies (ICT) in the physical education of students (Born, Nguyen, Grambow, Meffert, & Vogt, 2018; Siregar, Kasih, & Pardilla, 2022). According to the requirements of the time, the global development of ICT necessitates significant changes in all aspects of the organization of physical education and physical training in universities, which are able to raise the quality of this process to a significantly higher level (Di Tore, Schiavo, & D'isanto, 2016).

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Analysis of recent research and publications. The use of innovative technologies in the practice of physical education is considered in a fairly wide range of scientific papers (Capobianco, Almuklass, & Enoka, 2018; Chow, Chung, Ma, Macfarlane, & Shirley, 2017). It is considered that their active implementation and use is one of the most important priorities for the development of the industry in accordance with today's challenges (Born, Nguyen, Grambow, Meffert, & Vogt, 2018; Koryahin, Mykytyuk, Blavt, Dolnikova, & Stadnyk, 2020).

It is believed that an important mechanism of influence and management in the course of physical education is control (Ivashchenko, & Khudolii, 2016; Magill, & Anderson, 2017; Solohubova, Lakhno, Shyyan, & Shyyan, 2020). Improvement of technologies of pedagogical control is considered as a possible direction of increase of quality and efficiency of physical education of students. The target direction of control is to analyze the relationship between the dynamics of pedagogically oriented actions and pedagogically determined changes during physical training (Vanhelst, Beghin, Fardy, Ulmer, & Czapllicki, 2016). Control as a means of improving the system of information support for the management of the process of physical education is considered in a large list of works (Di Tore, Schiavo, & D'isanto, 2016; Ivashchenko, Yermakova, Cieslicka, & Muszkieta, 2015; Kriventsova, Pashkevych, Iermakov, Bartík, Michal, Nosko, & Yermakova, 2017).

The growing importance of comprehensive control in physical education and management of this process is due to many factors characteristic of the current state of the field of physical education (Edwards, 2010; Khudolii, Iermakov, & Ananchenko, 2015). Among the main ones, it is believed, is the lag in the quality of comprehensive control from the requirements for the organization of the training process, as well as increasing the requirements for metrological support for the collection and analysis of information (Chow, Chung, Ma A.W.W, Macfarlane, & Shirley, 2017; Koryahin, Mykytyuk, Turchyn, Blavt, Prystynskyi, & Stadnyk, 2021).

It is believed (Kok, Komen, van Capelleveen, & J. van der Kamp, 2020; Koryahin, Blavt, Vanivska, & Stadnyk, 2020) that all these issues are most effectively addressed in the case of the introduction of automated techniques that allow you to monitor the status of the main parameters in real-time. A special role is given to information technology of automated control and evaluation of acquired skills (Magill, & Anderson, 2017). The integration of ICT in the educational process provides the establishment of facts, identification of links and patterns, and forecasting of the consequences to improve the effectiveness of this process (Chow, Chung, Ma, Macfarlane, & Shirley, 2017; Siregar, Kasih, & Pardilla, 2022).

The purpose of this study is experimental substantiation to implement ICT in test control of back muscle strength in the process of physical education of students.

Materials and methods

Study participants

The first-year students from Lviv Polytechnic National University were selected for research. The study involved 240 students, their age at the beginning of the study was 17-18 years. It is important that the number of students in the

research groups was sufficient for the demonstrable evaluation of the experiment's results. The requirements for the adequacy of the information volume at the level of $p < 0.05$ were met.

The organization of the study took into account the provisions of the Declaration of Helsinki 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 the Lviv Polytechnic National University.

Study organization

Research methods. In accordance with the goal, the study required implementation at the theoretical and empirical levels, in accordance with modern requirements for research.

At the theoretical level, the following are applied: general scientific methods: analysis (analytical, structural-target, problem-oriented) to obtain theoretical and empirical material; synthesis and generalization of information presented in the scientific literature, documentary, and methodological sources (to clarify the theoretical aspects of the problem, their state, and development; to establish methods, levels of implementation, research approaches to research); induction and systematization (for processing of theoretical data, formulation of the basic provisions of research and their systematization in the context of the considered problems).

The methods used to obtain empirical data were the pedagogical experiment, pedagogical testing, and mathematical methods for processing digital files. Technical modeling was used as a method of the empirical level of research. Technical modeling was used to create an ICT-based device to be studied.

Organization of research. The scientific research was carried out in the process of interrelated stages of theoretical and empirical research.

Pedagogical testing involved determining muscle strength in the traditional way and using a developed device. This determined the strength of the torso flexors, torso and extensor muscles, or the strength of the back extensor muscles.

A back dynamometer (dynamometer from Baseline Products) and a wide belt with a buckle were traditionally used to determine back muscle strength. Measurements were performed using a gymnastic wall.

The strength of the back muscles is a total indicator of the group of muscles that perform flexion and extension of the torso. Determination of torso flexors was performed in a sitting position on the floor with the back to the gymnastic wall (chain - dynamometer - chain to wall system in the belt loop on the chest, Fig. 1.a). To avoid moving to the wall, the student rests his pelvis on a gymnastic bench placed on the edge, which is held by another person. Efforts are directed forward, arms bent at the elbows. The strength of the torso extensors was determined from the starting position sitting on the floor facing the gymnastic wall.

We also measured strength, which is a total measure of the group of muscles that stretch the torso. To determine it, the student becomes the middle of the feet on a metal platform with a hook and holds the dynamometer handle at the level of the knee joints, gripping from above.

The strength was determined as follows: the student stands with his feet on a wooden platform with a dynamometer attached to it, using a hook so that it is at knee level. Bending at the waist, the student takes the handle of the dynamometer with both hands and, without bending the knees, straightens his back and squeezes to failure. The study is conducted twice, the best result is recorded. Measurements are made with an accuracy of 5 kg.

Statistical analysis

Within descriptive statistics, the comparative-statistical method of determining of empirical authenticity of tests is applied. To determine the empirical authenticity of the tests, variance and correlation analysis (between the obtained test results and the correlation criterion) were used. Quantitatively, the degree of authenticity of the tests is expressed using the reliability and validity coefficients, which are calculated using the intra-class correlation coefficient. The methods of mathematical statistics are used, it can be confirmed that the criteria of reliability and validity are adequately met. All statistical analysis was performed using SPSS Version 20.

The statistical data required for the interpretation of the studied parameters were obtained by sampling two samples of 120 people of the same sex aged 18 to 22 years. The sample was considered as an empirical analog of the general population, which made it possible to form an opinion about the numerical values of the studied parameters as a whole.

Results

The effectiveness of all types of physical activity and ensuring a high level of efficiency limits the development of strength abilities, which are also an important component of the physical fitness of students. Compared to other motor abilities, power abilities are the most multi-component in structure and measurement and are the basis of their development (Ivashchenko, Yermakova, Cieslicka, & Muszkiet, 2015; Prieske, Muehlbauer, & Granacher, 2016). That is why specialists pay a lot of attention to the methods of control and improvement of these characteristics of muscular work (Alfrey, & Gard, 2014; Khudolii, et al., 2015).

The issue of control of the indicator of strength abilities is one of the determining factors that regulate the dynamics of physical fitness and allows you to purposefully manage this process. From the standpoint of the theory of abilities, the structure of these abilities is the least prone to adjustment and change (Edwards, 2010).

The muscular strength of the back is distinguished by the structure of strength abilities (Catalá, Schroll, Laube, & Arampatzis, 2018). There is a very strong muscle group in the back, which is the basis of a properly formed musculo-skeletal system and ensures its proper functioning. Research of means and methods of force training is considered one of the most priority directions of modern intelligence (Ivashchenko, Yermakova, Cieslicka, & Muszkiet, 2015).

Quantitatively, the level of development of strength abilities in the practice of physical education of students is assessed using special control exercises - strength tests (Magill, & Anderson, 2017). This process is technically complex, as testing involves maintaining balance by the student, which can lead to errors in the results. It is impossible to

intensify the test process, as it requires constant registration of results.

In order to eliminate the listed factors, objectify the assessment, and to ensure the reliability of the test results, a device was developed and tested, the readings of which allow receiving clear current information on the panel of the personal computer. In the presented electronic device for determining the strength of the back muscles, the system "chain-dynamometer-chain" is replaced by a rubber band with a known coefficient of elasticity (Fig. 1). When performing the test, the bending and unbending force of the torso will be proportional to the coefficient of elasticity and the amount of deformation.

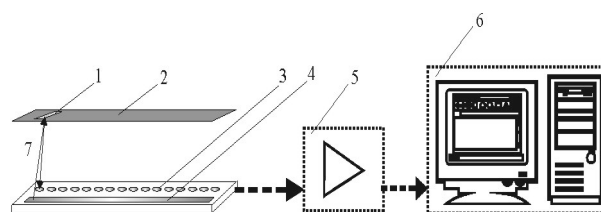


Fig. 1. Block diagram of a device for determining the strength of the back muscles: 1 – light reflector; 2 – rubber tape; 3 – line of photodetectors; 4 – radiation source; 5 – amplification unit based on the operational amplifier; 6 – personal computer; 7 – the course of the rays

The following scheme has been developed to fix the amount of deformation. A light reflector is attached to the rubber band. A wide-spectrum LED that covers the visible range is used as the light source. Opposite the rubber band on the rack is a line of photodiodes, which registers the signal that falls on a particular photodiode (Hotra, Mykytyuk, Diskovskyi, Barylo, & Vezyr, 2018). During the flexion and extension of the torso by the student in the testing process is stretching the elastic band and displacement of the reflector due to its deformation, and hence change the position of the reflected beam, which is fixed by photodiodes. The value of the deformation of the rubber band is equal to the signal from the corresponding photodiode on which the radiation hit. The signal from the photodiodes is amplified by an operational amplifier and fed to the screen of a personal computer. Visual information about the strength of the back muscles is generated on a personal computer using the developed software.

The expediency of using LEDs in our development is that such a sensor has advantages that significantly differentiate it from others, among them: high level of accuracy, speed, and resolution, minimum size, lack of sensitivity to external influences (vibration, etc.), low energy consumption level. In addition, LEDs have a great advantage: the brightness of the LEDs is very well adjustable, the ability to focus the light flux in one direction of its increased energy efficiency, and almost no negative environmental impact. Due to some physical properties, LEDs have a so-called instantaneous start. In its structure, the LED is similar to a conventional semiconductor diode, just like any semiconductor diode, the LED has the property of unilateral conductivity (Vistak, Dmytrah, Mykytyuk, Sushynskyi, Barylo, Prysiazhniuk, & Horbenko, 2017).

Table 1. Authenticity of student control tests of back muscle strength (n - 240)

	T	A	T	A	T	A	T	A	T	A	T	A
H	0,766	0,758	0,734	0,715	0,782	0,692	0,666	0,611	0,911	0,953	0,899	0,872
B	0,121	0,310	0,176	0,293	0,076	0,277	0,113	0,271	0,105	0,315	0,101	0,328

* Note: H – reliability of the test, B – validity of the text T – the traditional way, A – using the developed tool

The back muscle strength tester can use an optocoupler to record signals: an optoelectronic semiconductor device consisting of an emitter and a radiation receiver, between which there is an optical link and electrical insulation. In the electronic “circuit”, the optocoupler performs the function of a communication element, in which the electrical isolation of input and output is performed. At the same time, the unidirectionality of information flow through the channel is ensured, there is no feedback of the receiver to the signal. Optocoupler is characterized by physical and structural-technological compatibility with microelectronic devices (Wojcik, Vistak, Mykytyuk, Politskyi, Diskovskyi, Sushynskyi, Kremer, Prystay, Jaxylykova, Shedreyeva, 2020).

In the case of using an optocoupler in the developed device, the light reflector will be implemented on a rubber band in the form of alternating dark and light stripes. Data transmission in the control device is provided by wireless information transmission devices – Bluetooth.

The combination of the necessary analysis of the obtained control results with the visual form of presentation in the developed device is implemented by the software. The use of software allows simultaneous analysis of test results of a group of students without loss of information. The software includes recording and mathematical programs that quickly process the obtained control results using the methods of multidimensional mathematical analysis. At each current test time, only the required measurement elements are visible on the screen, other graphic objects are hidden. It also allows you to get a dynamic picture of the process, which significantly expands the informativeness of the test control.

Our development provides for automatic receipt of the results of multiple tests in the form of an electronic protocol. Numerous control data are written to files stored on disk, so it is available for further processing. Instant availability of information materials allows you to plan practical actions based on reliable information, therefore, you can significantly influence the improvement of organizational forms of physical education for students.

Thus, the unification and intensification of obtaining and processing control results is ensured. The software implements the accumulation, updating, adjustment and multifaceted use of a large array of information stored in a centralized database and automatic receipt of multiple test results in the form of an electronic protocol. The use of the developed device in the process of testing the strength of the back muscles provides simplification and automation of control procedures, accuracy and efficiency of testing, consisting of information retrieval time (usually up to 60 s), review time and analysis of results. Long-term observation throughout the period of physical education of students involves updating the results of control and storing them in a database in the format of hypertext arrays, which ensures the formation of information space at a qualitatively new level.

For the practical substantiation of the developed device for control of back muscle strength, correlation analysis has empirically investigated the degree of authenticity of tests used to control back muscle strength. To do this, the results of testing students of research groups, which were used as a retest, in three exercises to determine the strength of the back muscles: flexion of the torso, stretching of the torso, and posture. The test results were recorded traditionally and using the developed device (Tab. 1).

According to the results of the reliability of the tests of back muscle strength control tests, the results of which were recorded using a dynamometer is between low and medium, which is considered acceptable. The coefficient of validity in numerical values corresponds to the limits of low and medium. The recording of the back muscle strength test with the developed device ensured the achievement of a high level of test authenticity.

The developed device for testing the strength of the back muscles is characterized by ease of use and compact size of the device, and its use ensures the absence of human influence on the results of control.

Discussion

Ensuring the quality of physical education of university students is due to a number of factors, in the list of which control plays an important role. Control in physical education is positioned as an important component of managing the process of physical training (Khudolii, Iermakov, & Ananchenko, 2015). Management provides analysis of test results, which is the basis of operational corrective decisions. The tool in this case is the possibility of implementing operational control (De Oliveira, Arrebola, De Oliveira, & Liu, 2021). Our research is consistent with the information on the need to ensure the possibility of obtaining objective results as a basis for adjusting physical education plans for students (Ivashchenko, & Khudolii, 2016; Koryahin, Mykytyuk, Blavt, Dolnikova, & Stadnyk, 2020; Chernenko, Muszkiet, Dolynniy, Oliynyk, & Honcharenko, 2022).

The study integrates scientific ideas that progress in the field of knowledge of the theory and methods of physical education, increasing the importance of the scientific component, and requires the development of automated control using the potential of ICT (Kok, Komen, van Cappelleveen, & Van der Kamp, 2020; Zanevskyy, & Labartkava, 2020). The implementation of information processes of collecting, accumulating, storing, transmitting, processing and presenting (displaying) information of test control of back muscle strength in physical education of students using ICT ensures the effectiveness of the control process, which is consistent with the ideas presented in existing research (Chow, Chung, Ma, Macfarlane, & Shirley, 2017; Koryahin, Mykytyuk, Turchyn, Blavt, Prystynskyi, & Stadnyk, 2021).

Informatization of the control of physical education of university students presupposes the transition to a qualita-

tively new level of its efficiency (Born, Nguyen, Grambow, Meffert, & Vogt, 2018; Koryahin, Blavt, Vanivska, & Stadnyk, 2020). At the heart of this direction is a technological approach to the implementation of test control, aimed at ensuring its high efficiency, which integrates existing scientific ideas in this direction. This approach makes it possible to systematize the direction of research in this field of knowledge in order to obtain objective and comprehensive information for the effective implementation of management functions in the process of physical training (Alfrey, & Gard, 2014; Estivalet & Springer, 2009).

The obtained scientific results are represented in the software's complex information and communication support. In this way, there is a unification and intensification of obtaining and processing test results, which generally reorganizes the procedure of control of students' strength abilities and increases the level of information support.

We support scientific ideas on the introduction and use of modern ICT in the process of control of physical education to ensure the reliability and efficiency of this process. In turn, it is possible to implement forecasting, design individual components of classes and evaluate the effectiveness of the process of physical education for students while studying at the university (Anikieiev, 2015; Koryahin, Blavt, Vanivska, & Stadnyk, 2020).

Determining the reliability of tests used to control back muscle strength confirms the data (Edwards, 2010; Vanhelst, Beghin, Fardy, Ulmer, & Czaplicki, 2016) that tests measured by mechanical dynamometers are quite unreliable. It is confirmed (Koryahin, & Blavt, 2019; Magill, & Anderson, 2017), that the level of reliability of the test is not an absolute indicator and depends on the method of obtaining test results. Thus, there is a change in the degree of reliability of the tests depending on how the results are recorded.

The obtained results expand and supplement the information on the possibilities of modernization of physical education of students on the basis of integration of the latest ICT to ensure the implementation of this process at the modern scientific level as a factor of its effectiveness in terms of health (Kok, Komen, van Capelleveen, & J. van der Kamp, 2020; Koryahin, Iedynak, Blavt, Galamandjuk, Prozar, Zai-kin, Veselovska, Golub, Kucher, & Gurtova, 2019). The new scientific results presented in the work are aimed at reorganizing the procedures of control of physical education of students and increasing the level of its information support, which meets modern standards. Adaptation of teachers and students to the information society allows for a new type of educational service.

Conclusions

According to the results of the study, a new approach to the implementation of the procedure of testing the strength of the back muscles in physical education of students using the potential of modernization and strengthening the processes of informatization in physical education of students based on ICT. The developed device of registration of test results is scientifically substantiated and represented.

The novelty and practical significance of the ICT-based back muscle strength testing device lies in the ability to ensure the efficiency and high efficiency of the procedure of monitoring the strength abilities of students, the result of

which is the prompt receipt of reliable measurement data. In case of their inconsistency, the necessary decisions are made and adjustments are made to the process of physical training.

The paper presents a new approach to solving the problem of improving the effectiveness of control in physical education of students, which meets modern standards. The use of an ICT-based back muscle strength monitoring device has been experimentally substantiated. In the obtained values of the degree of authenticity of the tests there is a change in the degree depending on the method of recording the results. Based on the results obtained, we can conclude that the reliability of the same test depends on the method of recording the results.

The result of scientific research aimed at solving the problematic aspects of test control was to ensure the appropriate degree of authenticity of tests used to control back muscle strength. Developed software complex automated control and evaluation of back muscle strength parameters, unifies and intensifies the receipt and processing of test results. All this provides modernization of the control process in the physical education of students and is a significant contribution to its implementation at the modern scientific level.

Conflict of interest

The authors state no conflict of interest.

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ІНТЕСТИФІКАЦІЯ ТЕСТОВОГО КОНТРОЛЮ СИЛИ М'ЯЗІВ СПИНИ У ФІЗИЧНОМУ ВИХОВАНІ СТУДЕНТІВ НА ОСНОВІ ІНФОРМАЦІЙНО-КОМУНІКАЦІЙНИХ ТЕХНОЛОГІЙ

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Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; Е – збір коштів

Реферат. Стаття: 7 с., 1 табл., 1 рис., 30 джерел.

Мета дослідження полягала у експериментальному обґрунтуванні та упровадженні інформаційно-комунікаційних технологій у тестовий контроль сили м'язів спини в процесі фізичного виховання студентів.

Матеріали та методи. Для вирішення завдань дослідження використовувалися загальнонаукові методи: аналіз, синтез, узагальнення, індукція та систематизація, технічне моделювання, педагогічний експеримент, педагогічне тестування, математичні методи. У дослідженні взяли участь 240 студентів, їх вік на початок дослідження становив 17-18 років.

Результати. Розроблено та апробовано електронний пристрій для визначення сили м'язів спини, показання якого дозволяють отримати чітку поточну інформацію на панелі персонального комп'ютера. Пристрій побудований на поєднанні сучасних електронних технологій і програмного забезпечення. Для експериментального обґрунтування розробленого пристрою для контролю сили м'язів спини кореляційним аналізом емпірично досліджено ступінь

достовірності тестів, що використовуються для контролю сили м'язів спини. За результатами дослідження автентичність тестів контролю сили м'язів спини, результати яких реєструвалися за допомогою динамометра, знаходиться між низьким та середнім рівнем. Реєстрацією результатів контролю сили м'язів спини за допомогою розробленого пристрою забезпечили досягнення високого рівня достовірності тестів.

Висновки. Результатом наукових досліджень, спрямованих на вирішення проблемних аспектів тестового контролю, стало забезпечення належного ступеня достовірності тестів, що використовуються для контролю сили м'язів спини у фізичному вихованні студентів. Реєстрація результатів тестових вправ з використанням презентованого приладу забезпечує досягнення високого рівня достовірності тесту.

Ключові слова: тестування, контроль, фізичне виховання, студент, сила м'язів спини, пристрій, інформаційно-комунікаційні технології.

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