Теорія та методика фізичного виховання
Physical Education Theory and Methodology
Teorìâ ta Metodika Fìzičnogo Vihovannâ

ISSN 1993-7989 (print)
ISSN 1993-7997 (online)
ISSN-L 1993-7989

Original Scientific Article

Estimating the Effect of Contrast Exercises Using Conventional Deadlifts and Air Rower on Increasing Leg Muscle Strength and VO_2max in Rowing Athletes

Nurkholis[1ABDE], Dwi Cahyo Kartiko[1BCD], Irmantara Subagio[1ABD], Andri Suyoko[1ABD] and Adi Pranoto[1ABCD]

[1]Universitas Negeri Surabaya

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

Corresponding Author: Nurkholis; E-mail: nurkholisnurkholis@unesa.ac.id
Accepted for Publication: November 11, 2024
Published: December 10, 2024

DOI: 10.17309/tmfv.2024.6.12

Abstract

Objectives. This study aimed to prove the effect of contrast training using conventional deadlifts and air rowers on the increase of leg muscle strength and VO_2max in rowing athletes.

Materials and methods. This study used a true-experimental method with a two-group pretest-posttest approach, involving a control group design. A total of 22 rowing athletes, aged 19-23 years, and recruited from the Surabaya City training centre, were involved in the study. The athletes received a contrast training intervention with a high intensity of 85-90 % 1RM, conducted thrice per week for a six-week period. Leg strength and back strength, leg power, and VO_2max were evaluated between pre- and post-intervention in each study group.

Results. The results showed that leg strength and back strength, leg power, and VO_2max were found to be significantly improved after performing a contrast exercise intervention compared to the control group ($p \leq 0.05$).

Conclusions. These findings suggest that contrast training combining conventional deadlifts and air rowers is an effective method of increasing leg muscle strength and power, as well as VO_2max in rowing athletes, so that it can provide benefits to enhance the explosive strength and aerobic endurance of these athletes.

Keywords: explosiveness, rowing athletes, aerobic endurance, contrast training.

Introduction

In rowing sports, efficient and explosive movements start from the push of the legs, which is the main source of power for moving the boat (Vieira et al., 2020). The leg muscles, especially the quadriceps, hamstrings, gluteus, and gastrocnemius, play a crucial role in generating initial strength during each cycle of rowing movements (Cardoso et al., 2024). Rowing athletes harness the strength of their leg muscles to provide a strong push, which is then followed by the contribution of the back and arm muscles (Chang et al., 2024). Rowing is a complex activity involving kinetic chains that start from the push of the legs and move through the upper body until reaching the pull of the paddle (Cady-McCrea et al., 2024). Therefore, leg muscle strength is essential in effectively transferring energy from the lower body to the upper body (Vieira et al., 2020).

Posture control and stability are indispensable for rowing athletes to maintain technical efficiency in each movement (Duchene et al., 2024). Strong leg muscles not only support force transfer but also contribute to postural stability, ultimately improving rowing technique as well as reducing errors that can affect performance (Chang et al., 2024). Additionally, in race situations, especially at the start and finish, rowing athletes need explosive power to provide maximum acceleration in a very short time (Cardoso et al., 2024). Leg muscle strength plays a key role in this critical phase, where rapid acceleration and explosive thrust can be the difference between victory and defeat (Chang et al., 2024).

In addition to the importance of explosiveness, stability and balance when rowing also depend on the strength of the leg muscles (Promsri et al., 2018; Alonso et al., 2011). If this force is insufficient, the distribution of the load during rowing becomes unbalanced, which increases the risk of injury, especially in the back, knees, and ankles (Zemková, 2022; Podgórski et al., 2020). Previous research has shown that optimal leg muscle strength is a predictor of success in rowing competitions (Thiele et al., 2020; Lawton et al., 2013; McNeely et al., 2005).

To increase the strength of the leg muscles, several exercise methods can be used. One of them is contrast training, which is an exercise method that combines heavy weight training with explosive training in one session (Barra-Moura et al., 2024; Paulo Henrique Pauli et al., 2023). Deadlift is one of the most effective exercises in increasing posterior kinetic chain strength in athletes, including rowing athletes, because it involves many muscle groups, especially lower body muscles (Cholewa et al., 2019). Previous research has shown that high-load resistance training (≥ 85% of 1RM) is effective for improving explosive strength and performance (Hagerupsen et al., 2024; Cormie et al., 2010; Comfort et al., 2012; Øvretveit & Tøien, 2018).

In addition to deadlifts, the use of tools such as air rowers in contrast training programs can provide explosive exercises that mimic the specific movements of the paddles (Thiele et al., 2020). Air rowers help to train the leg and upper body muscles simultaneously, as well as improve cardiovascular capacity and explosiveness (Chang et al., 2024). The combination of deadlift as a weight exercise and air rower as an explosive exercise in a contrast training program is expected to increase leg muscle strength more effectively compared to conventional methods.

This study aims to prove the effect of contrast training that combines conventional deadlift training and air rowing training on increasing leg muscle strength in rowing athletes. Based on previous research that shows the effectiveness of weight and explosive training, this research is expected to make a significant contribution to the understanding of optimal training programs for rowing athletes.

Materials and Methods

Study Design

This study uses a true experimental method with two group pretest-posttest with a control group design. A total of 22 rowing athletes were recruited from the Surabaya City training center aged 19-23 years and divided into two study groups, namely the control group (CTR; n = 11), the contrast training group (CNT; n = 11). CTRs did not receive any training interventions, while CNT received 3x/week interventions for 6 weeks. All subjects voluntarily gave consent to participate by filling out and signing the consent given by the researcher and all procedures applied in this study have complied with the Helsinki World Medical Association Declaration on the ethical conduct of research involving human subjects.

Contrast Training Methods

This Contrast Training program focuses on increasing maximum power and explosive power, starting with the Conventional Deadlift at 85% 1RM load and Air Rower at 30% 1RM load. In weeks 3 and 4, the intensity increases with conventional deadlifts using 90% 1RM (3 sets, 3 reps, 15 seconds rest), while air rowers remain at 30% 1RM (3 sets, 5 reps, 3 minute rests). In weeks 5 and 6, the intensity increases further with conventional 90% 1RM deadlifts (3 sets, 3 reps), but the rest time is trimmed to 10 seconds, forcing the body to adapt to a faster transition between maximum strength training and explosive training. Air rower training remains at the same intensity, helping to maintain focus on explosiveness. This improvement aims to stimulate higher muscle and nervous system adaptation, optimizing strength and speed performance at the end of the intervention program. The frequency of Contrast Training is carried out 3x/week for 6 weeks.

Data Collection

Data collection was carried out by measuring leg strength and back strength using a foot dynamometer with the subject pulling the handle with maximum force in the semi-squat position (for leg strength) and the bending position with a straight back (for back strength). The data is generated from the measurement of leg strength and back strength in kilograms (kg). Leg strength, force plates are used through tests such as reverse motion jumps or squat jumps, where the force plates measure the vertical force generated during jumps. From the force and contact time data, power is calculated in watts (force × speed). Meanwhile, VO_2max was measured through a maximum rowing test of 2000 meters, with the subject rowing on an air rower as far as 2000 meters with maximum effort. Travel time is used to predict VO_2max using a formula that takes into account weight, age, and gender, as an indicator of aerobic capacity. These four parameters provide important data for evaluating the muscle strength, explosiveness, and aerobic capacity of rowing athletes.

Statistical Analysis

All statistical analyses are applied with SPSS Version 21.0. The stages of statistical analysis include descriptive tests, normality, and hypothesis tests with paired sample t-tests and independent sample t-tests applied in this study. The data was stated to have a significant difference in hypothesis testing if $p \leq 0.05$.

Results

The results showed that in general, the data on the characteristics of the research subjects in each study group did not show significant differences which can be seen in more detail in Table 1 below. Meanwhile, the results of the analysis of leg strength and back strength, leg strength, and VO_2max between pretest and posttest in each study group are presented in Figure 1-2.

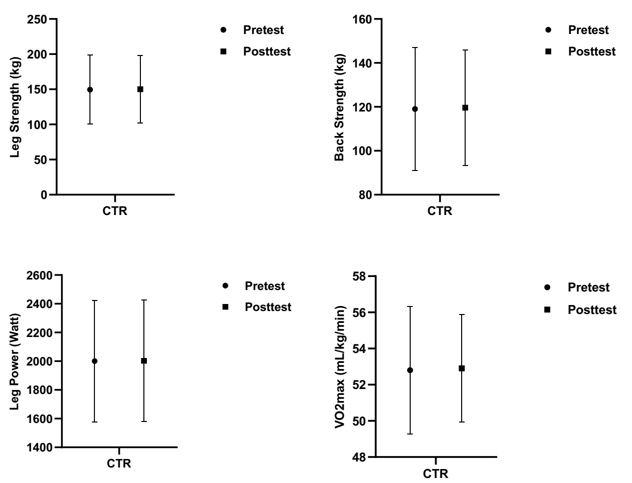

Fig. 1. Differences in leg strength and back strength, leg strength, and VO_2max analysis in the control group (CTR) between pretest and posttest. Description: Data was presented with an mean ± SD. The p-value was obtained by analysis of the paired sample t-test

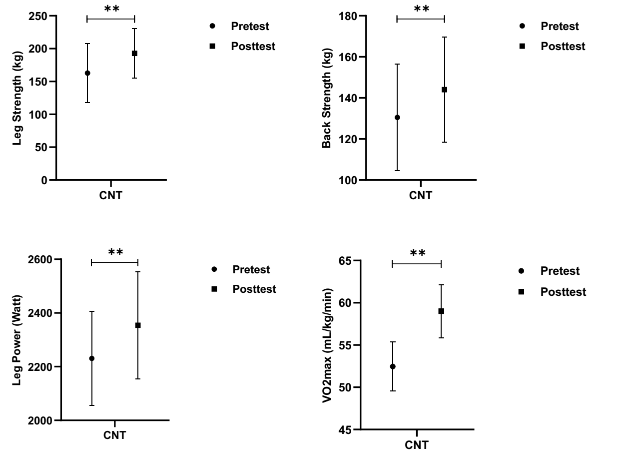

Fig. 2. Differences in leg strength and back strength, leg strength, and VO_2max analysis in the contrast training group (CNT) between pretest and posttest. Description: Data was presented with an mean ± SD. The p-value was obtained by analysis of the paired sample t-test. (**) Significant at pretest (p ≤ 0.001)

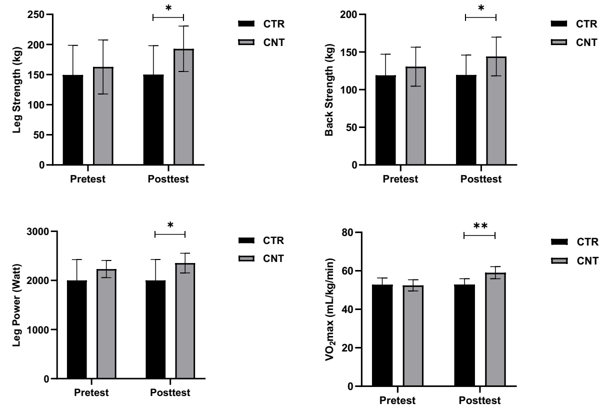

Fig. 3. Differences in leg and back strength, leg power, and VO_2max analysis between CTR vs CNT. Description: Data is presented with an mean ± SD. p-value was obtained by analysis of independent sample t-test (*) Significant at pretest (p ≤ 0.05). (**) Significant at pretest (p ≤ 0.001)

Table 1. General characteristics of the subject of study

Parameters	Unit	CTR (n = 11)	CNT (n = 11)	p-value
Age	yrs	20.64 ± 1.21	20.91 ± 1.14	0.591
Height	m	1.77 ± 0.05	1.78 ± 0.04	0.999
Body weight	kg	65.46 ± 5.36	68.73 ± 3.52	0.108
Body mass index	kg/m^2	20.88 ± 1.91	21.91 ± 0.74	0.116
Baseline Leg strength	kg	149.55 ± 49.21	162.73 ± 44.87	0.519
Baseline Back strength	kg	119.05 ± 28.08	130.50 ± 25.85	0.331
Baseline Leg power	watt	2000.46 ± 423.28	2230.64 ± 174.63	0.119
Baseline VO_2max	mL/kg/min	52.81 ± 3.52	52.47 ± 2.91	0.806

Description: Data was presented with an mean ± standard deviation (SD). p-values were obtained by independent sample t-test analysis. RKT: Control group; CNT: Contrast training group

Discussion

This study aims to prove the effect of contrast training by combining conventional deadlift and air rower exercises in increasing leg muscle strength and power as well as VO_2max in rowing athletes. Based on the results of the study, it was found that the group that participated in contrast training showed a significant increase in leg muscle strength compared to the control group. These findings provide strong evidence that the combination of weights and explosive exercises is not only able to increase strength, but also effectively develop the ability of athletes to produce the explosive power needed in the critical phase of rowing (Gee et al., 2014; McGregor et al., 2004).

The rowing movement begins with a leg push, in which the quadriceps, hamstrings, gluteus, and gastrocnemius muscles play a dominant role in generating initial strength. Conventional deadlift training in contrast training programs focuses on strengthening these muscles through high loads (Haff et al., 2001; Swinton et al., 2011), while air rowers add explosive elements that mimic the movement of the paddles themselves. In this context, the increase in strength gained from conventional deadlift training can be optimized through explosive exercises with air rowers, which simultaneously reinforce the relationship between leg strength and power transfer to the upper body during rowing (Seitz & Haff, 2016).

In addition, the results of this study also corroborate the findings of several previous studies that show that combined exercise between heavy weight training and explosive training can improve the performance of athletes in various sports disciplines (Tillin & Bishop, 2009). The increased power gained through contrast training allows athletes to accelerate quickly, especially at the beginning of a race, when maximum explosive thrust is required (Cardoso et al., 2024). In addition, explosive exercises such as those simulated through air rowers also help sharpen the explosive abilities necessary to maintain speed when reaching the finish line.

Contrast exercises that combine conventional deadlifts and air rowers are not only effective in improving leg muscle strength, but can also bring great benefits in posture stability and efficiency of rowing techniques. Previous studies have shown that postural stability is essential for maintaining optimal performance in sports that involve repetitive movements such as rowing (Wilson et al., 2013). In rowing sports, posture imbalances or incorrect load distribution can not only reduce movement efficiency, but also increase the risk of injury, especially in the lower back (Caldwell et al., 2003). By strengthening the leg muscles through weight exercises such as conventional deadlifts, athletes can maintain better posture during the rowing cycle, ultimately reducing the unbalanced load on the back and upper body (Swinton et al., 2011).

Additionally, the use of air rowers in explosive training helps to improve explosive capabilities, which are indispensable during critical phases such as starting and finishing in races (Chang et al., 2024). These phases require maximum explosive thrust from the leg muscles, and this combination of exercises provides the right stimulus to develop those abilities. Contrast training programs that integrate sport-specific exercises, such as air rowing, also support the improvement of rowing techniques. This supports the claim that explosive training can improve athletes' performance in sports that require endurance and muscle strength, as revealed by previous research (Barra-Moura et al., 2024).

However, the results of this study are inseparable from several limitations that need to be considered. One of the main limitations is the relatively short duration of the study. Although we found a significant increase in leg muscle strength after a contrast training program, we have not been able to explore the long-term effects of this exercise. Previous research has shown that some of the positive effects of explosive and weight-bearing exercises may take longer to maintain or even reach their maximum potential (Tillin & Bishop, 2009). Therefore, longitudinal studies that monitor the development of strength and performance of athletes over a longer period of time are needed to determine whether the benefits of contrast training are long-term or temporary.

In addition, the variability of individual responses to sports programs is also a factor that has not been fully researched in this study. Each athlete may have a different level of adaptation to a training program, depending on factors such as previous training experience, initial physical condition, and fitness level. For example, some athletes may develop muscle strength faster than others, or conversely, some may take longer to achieve optimal results. This is in line with the findings of Seitz and Haff (2016), which highlights that athletes' responses to Post-Activation Potentiation (PAP) and contrast training can vary greatly depending on the individual's condition.

Further research should include a more diverse population of athletes, both in terms of fitness levels and experience in rowing, to get a more comprehensive picture of the effectiveness of these programs. In addition, more in-depth research is also needed to explore how contrast training can be adapted in the preparation phase of the competition and the recovery phase of athletes. In this context, it is important to understand whether this type of exercise is more effective when applied to specific phases in the training cycle, such as when the athlete is at the peak of fitness or in the early adaptation phase (Cormie et al., 2010).

These findings provide a solid basis for coaches to consider contrast training in rowing athlete training programs to improve strength and overall performance. Although the results were positive, the study had limitations, especially regarding the short duration and variability of individual responses that had not been studied in more depth. More research focusing on the long-term effects and adaptation of training in different populations of athletes is needed to reinforce these findings.

Conclusion

Overall, the results of this study suggest that contrast exercises that combine conventional deadlifts and air rowers are an effective method for increasing leg muscle strength and power as well as VO_2max in rowers. In addition to providing benefits in improving explosive power and aerobic endurance, the exercise also supports postureal stability and efficiency of rowing techniques, both of which are important for maintaining optimal performance and reducing the risk of injury. As such, trainers and fitness experts may consider incorporating this exercise program into an athlete's workout routine, especially for those looking to improve their explosive and aerobic endurance in rowing.

Conflict of Interest

The authors state that they have no competing interests.

References

Vieira, T.M., Cerone, G. L., Stocchi, C., Lalli, M., Andrews, B., & Gazzoni, M. (2020). Timing and modulation of activity in the lower leg muscles during indoor rowing: What are the key muscles to target in the FES rowing protocol? *Sensor (Basel, Switzerland), 20*(6), 1666. https://doi.org/10.3390/s20061666

Cardoso, R., Rios, M., Cardoso, F., Fonseca, P., Ferreira, F. A., Jose Arturo Abraldes, Gomes, B. B., João Paulo Vilas-Boas, & Fernandes, R. J. (2024). Physiological and Biomechanical Characteristics of Olympic and World Class Rowers—Case Study. *Applied Science, 14*(10), 4273-4273. https://doi.org/10.3390/app14104273

Chang, C.H., Ho, C.S., Li, F., Chen, C.Y., Yeh, H.C., & Ho, C.A. (2024). Acute effects of the mechanical properties of muscles after rowing 2000 m in young male rowers. *PeerJ,* 12, e16737. https://doi.org/10.7717/peerj.16737

Cady-McCrea, C. I., Lawlor, M. C., Rodenhouse, T. F., Puvanesarajah, V., & Mesfin, A. (2024). Rowing Spine: Biomechanics, Injury, and Treatment Review. *World neurosurgery,* 187, 156-161. https://doi.org/10.1016/j.wneu.2024.04.032

Duchene, Y., Simon, FR, Ertel, G. N., Maciejewski, H., Gauchard, G. C., & Mornieux, G. (2024). The stroke rate affects the performance, technique, and stability of the core during the oarsman ergometer. *Sports biomechanics,* 1-18. Advanced online publications. https://doi.org/10.1080/14763141.2024.2301992

Promsri, A., Menide, T., & Federolf, P. (2018). How does the dominance of the lower limbs affect the postural control movement during the single leg position? *The science of human movement,* 58, 165-174. https://doi.org/10.1016/j.humov.2018.02.003

Alonso, A. C., Brech, G. C., Bourquin, A. M., & Greve, J. M. (2011). Effect of lower limb dominance on postural balance. *Medical journal of Sao Paulo = Revista paulista de medicina, 129*(6), 410-413. https://doi.org/10.1590/s1516-31802011000600007

Zemková, E. (2022). Strength and strength-related measures in assessing core muscle performance in exercise and rehabilitation. *Frontiers in Physiology,* 13. https://doi.org/10.3389/fphys.2022.861582

Podgórski, T., Nowak, A., Domaszewska, K., Mączyński, J., Jabłońska, M., Janowski, J., & Ogurkowska, M. B. (2020). Muscle strength and inflammatory response to exercise load in rowers. *PeerJ,* 8. https://doi.org/10.7717/peerj.10355

Thiele, D., Prieske, O., Chaabene, H., & Granacher, U. (2020). Effects of strength training on physical fitness and sport-specific performance in recreational, sub-elite, and elite rowers: A systematic review with meta-analysis. *Journal of Sports Science, 38*(10), 1186-1195. https://doi.org/10.1080/02640414.2020.1745502

Lawton, T. W., Cronin, J. B., & McGuigan, M. R. (2013). Strength, strength, and endurance training and elite paddle ergometer performance. *Journal of strength and conditioning research, 27*(7), 1928-1935. https://doi.org/10.1519/JSC.0b013e3182772f27

McNeely, E., Sandler, D., & Bamel, S. (2005). Strength and Power Goals for Competitive Rowers. *Journal of Strength and Conditioning, 27*(3), 10-15. https://doi.org/10.1519/00126548-200506000-00001

Barra-Moura, H., Vieira, J. G., Werneck, F. Z, Wilk, M., Pascoalini, B., Queiros, V., Assis, G. G. de, Bichowska-Pawęska, M., Vianna, J., & Vilaça-Alves, J. (2024). Effect of complex contrast training with different training frequencies on the physical performance of young football players: a randomized study. *PeerJ,* 12, e17103. https://doi.org/10.7717/peerj.17103

Paulo Henrique Pauli, Fernando, Pereira, M., Vinícius, M., Mayara Maciel Batista, & Marcus Peikriszwili Tartaruga. (2023). The Effect of Complex and Contrast Training on Strength, Power, and Agility in Professional Futsal Players: A Preliminary Study. *Journal of Science in Sport and Exercise.* https://doi.org/10.1007/s42978-023-00238-9

Cholewa, J.M., Atalag, O., Zinchenko, A., Johnson, K., & Henselmans, M. (2019). Determinants of Anthropometric Performance of Deadlift Variants. *Journal of sports science and medicine, 18*(3), 448-453.

Hagerupsen, K., Pedersen, S., Giller, N. B., Thomassen, N.K., Heitmann, K. A., Sagelv, E. H., Osborne, J. O., & Johansen, K. R. (2024). Comparison of resistance training using barbell half squats and trap bar deadlifts at maximum strength, strength performance, and lean mass in recreationally active women: an eight-week randomized trial. *BMC sports science, medicine & rehabilitation, 16*(1), 124. https://doi.org/10.1186/s13102-024-00911-8

Cormie, P., McGuigan, M. R., & Newton, R. U. (2010). Adaptation in athletic performance after ballistic strength versus strength training. *Medicine and science in sport and sport, 42*(8), 1582-1598. https://doi.org/10.1249/MSS.0b013e3181d2013a

Comfort, P., Haigh, A., & Matthews, M.J. (2012). Is the change in maximum squat strength during pre-season training reflected in the change in sprint performance in rugby league players? *Journal of strength and conditioning research, 26*(3), 772-776. https://doi.org/10.1519/JSC.0b013e31822a5cbf

Øvretveit, K., & Tøien, T. (2018). Maximum Strength training improves strength performance on grapplers. *Journal of strength and conditioning research, 32*(12), 3326-3332. https://doi.org/10.1519/JSC.0000000000002863

Gee, T. I., Caplan, N., Gibbon, K. C., Howatson, G., & Thompson, G. G. (2016). Investigate the effects of typical paddling strength training practices on strength and strength development as well as 2,000 m paddling performance. *Journal of Human Kinetics,* 50, 167-177. https://doi.org/10.1515/hukin-2015-0153

McGregor, A. H., Bull, A. M., & Byng-Maddick, R. (2004). Comparison of rowing techniques at different stroke speeds: description of sequencing, force production, and kinematics. *International journal of sports medicine, 25*(6), 465-470. https://doi.org/10.1055/s-2004-820936

Haff, G. G., Whitley, A., & Potteiger, J. A. (2001). Brief Review: Explosive Workouts and Exercise Performance. *Journal of Strength and Conditioning, 23*(3), 13. http://doi.org/10.1519/00126548-200106000-00003

Swinton, P.A., Lloyd, R., Agouris, I., & Stewart, A. (2009). Contemporary training practices in Britain's elite weightlifters: survey results from international competitions. *Journal of strength and conditioning research, 23*(2), 380-384. https://doi.org/10.1519/JSC.0b013e31819424bd

Seitz, L.B., & Haff, G.G. (2016). Factors Modulating Post-Activation Potentiation of Jump, Sprint, Throw, and Upper Body Ballistic Performances: A Systematic Review with Meta-Analysis. *Sports Medicine (Auckland, N.Z.), 46*(2), 231-240. https://doi.org/10.1007/s40279-015-0415-7

Tillin, N.A., & Bishop, D. (2009). Factors that modulate post-activation potentiation and its effect on the performance of subsequent explosive activity. *Sports Medicine (Auckland, N.Z.), 39*(2), 147-166. https://doi.org/10.2165/00007256-200939020-00004

Wilson, F., Gissane, C., & McGregor, A. (2014). The volume of ergometer training and previous injuries predict back pain when rowing; strategies for injury prevention and rehabilitation. *English Journal of Sports Medicine, 48*(21), 1534-1537. https://doi.org/10.1136/bjsports-2014-093968

Caldwell, J.S., McNair, P.J., & Williams, M. (2003). Effects of repetitive movements on lumbar flexion and erector spinae muscle activity in rowers. *Clinical Biomechanics (Bristol, Avon), 18*(8), 704-711. https://doi.org/10.1016/s0268-0033(03)00117-7

Оцінка впливу контрастних вправ з використанням традиційних станових тяг та веслувального тренажера з повітряною системою навантаження на підвищення показників м'язової сили нижніх кінцівок та рівня VO_2max у спортсменів-веслувальників

Нурхоліс[1ABDE], Дві Кахйо Картіко[1BCD], Ірмантара Субагіо[1ABD], Андрі Суйоко[1ABD], Аді Праното[1ABCD]

[1]Сурабайський державний університет

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

Реферат. Стаття: 6 с., 1 табл., 3 рис., 27 джерел.

Мета дослідження. Мета дослідження полягала в доведенні впливу контрастного тренування з використанням традиційних станових тяг і веслувальних тренажерів з повітряною системою навантаження на підвищення показників м'язової сили нижніх кінцівок і рівня VO_2max (максимальне споживання кисню) у спортсменів-веслувальників.

Матеріали та методи. В рамках цього дослідження застосовано метод «істинного експерименту» з використанням двогрупового перед- і післятестового підходів, що включає в себе дизайн контрольної групи. У дослідженні взяли участь 22 спортсмени-веслувальники віком від 19 до 23 років, які були відібрані з тренувального центру м. Сурабая. Спортсмени проходили програму контрастних тренувань з високою інтенсивністю 85-90 %, що складалися з одного повторення з максимальною вагою (1ПМ), які проводилися тричі на тиждень протягом шеститижневого періоду. У кожній досліджуваній групі визначали силу м'язів нижніх кінцівок та спини, потужність м'язів ніг і показник VO_2max між етапами перед і після проведення курсу тренувань.

Результати. Згідно з результатами дослідження, після виконання контрастного фізичного навантаження встановлено значне покращення показників силових якостей м'язів нижніх кінцівок та спини, потужності ніг та рівня VO_2max порівняно з контрольною групою ($p \leq 0,05$).

Висновки. Отримані дані свідчать про доцільність проведення контрастного тренування, що поєднує стандартні станові тяги та застосування веслувальних тренажерів з повітряною системою навантаження, як ефективного методу підвищення показників сили та потужності м'язів нижніх кінцівок, а також рівня VO_2max у спортсменів-веслувальників, що може сприяти поліпшенню вибухової сили та аеробної витривалості зазначеної категорії спортсменів.

Ключові слова: вибуховість, спортсмени-веслувальники, аеробна витривалість, контрастне тренування.

Information about the authors:

Nurkholis: nurkholisnurkholis@unesa.ac.id; https://orcid.org/0000-0002-5474-1045; Department of Sport Coaching Education, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Kartiko, Dwi Cahyo: dwicahyo@unesa.ac.id; https://orcid.org/0000-0002-6727-0879; Department of Physical Education, Health and Recreation, Faculty of Sports and Health Science, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Subagio, Irmantara: irmantarasubagio@unesa.ac.id; https://orcid.org/0000-0003-0265-7842; Department of Sport Coaching Education, Faculty of Sport and Health Science, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Suyoko, Andri: andrisuyoko@unesa.ac.id; https://orcid.org/0000-0001-6836-8731; Department of Sport Coaching Education, Faculty of Sport and Health Science, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Pranoto, Adi: adipranoto@unesa.ac.id; https://orcid.org/0000-0003-4080-9245; Department of Sport Coaching Education, Faculty of Sports and Health Science, Universitas Negeri Surabaya, Jl. Lidah Wetan, Lidah Wetan, Kec. Lakarsantri, Kota SBY, Jawa Timur 60213, Indonesia.

Cite this article as: Nurkholis, Kartiko, D. C., Subagio, I., Suyoko, A., & Pranoto, A. (2024). Estimating the Effect of Contrast Exercises Using Conventional Deadlifts and Air Rower on Increasing Leg Muscle Strength and VO_2max in Rowing Athletes. *Physical Education Theory and Methodology, 24*(6), 946-951. https://doi.org/10.17309/tmfv.2024.6.12

Received: 07.10.2024. Accepted: 15.11.2024. Published: 10.12.2024