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EFFECTS OF ECCENTRIC/CONCENTRIC TRAINING ON MORPHO-PHYSIOLOGICAL INDICATORS IN ELITE MALE VOLLEYBALL

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Abstract. *Strength training addresses the physiological needs specific to each sport or the position of each player and will have a positive influence on athletic training. Eccentric/concentric exercises are widely used as a means of modifying the morphological characteristics that will lead to an improvement in the physical training of players. The main effects of weight training are the development of maximal strength and explosive power by increasing muscle mass and decreasing body fat. In fast movements, strength acquires high values and sometimes exceeds isometric indices, and in slow movements, it gets values close to isometric ones. The purpose of this study is to design a physical training programme for strength development in volleyball players of the Ştiinţa Bucharest team. The experiment took place between 1 October and 21 December 2021, and therefore lasted 12 weeks. The participants in this experiment are members of the Ştiinţa Bucharest volleyball team. They were measured and tested at the beginning and the end of the competition schedule. After the winter training period, the obtained results had higher values, indicating that the means used and their dosage were effective. The methods and means used in the training programme guide the entire methodology of applying the independent variable. The results obtained from this research reveal that the independent variable of the study produces significant increases in both morphological characteristics and physical training.*

Keywords: *eccentric/concentric training, morphological characteristics, volleyball.*

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Introduction

In volleyball, as in other sports, training factors are interdependent and condition one another. Thus, the physical training factor in volleyball includes multilateral and specific components and should be regarded as indispensable in the training process. In the game of volleyball, there is a predominance of explosive movements (strength-speed) interspersed with ample skill and coordination movements. In this sport, innate motor skills need to be educated, developed in terms of both basic and specific aspects, in parallel with the preparation of other training factors. Muscle development has the effect of improving strength, which must show increasing signs of manifestation in different regimens and situations. The strength training of volleyball players should be oriented towards educating all forms of strength manifestation, but with an emphasis on explosive power, which is of great importance. Volleyball players have more advantage of “flexibility, muscular endurance, power and cardio-respiratory endurance” (Taware et al., 2013).

Muscle mass is particularly important for strength development and is measured by the circumference of body segments, where the fat layer should not exceed 0.4 cm. The increase in strength is achieved only through high muscle tension by using either medium, heavy and maximum weights or light weights at maximum speeds. Thus, in slow movements, strength gets values close to isometric ones.

For effective training, strength development should be done in three stages:

Stage 1 - Mastering the optimal technique of weightlifting exercises. This stage is very important because now the anatomical and functional basis necessary for subsequent weight training is being formed.

Stage 2 - This stage aims to increase muscle mass with a focus on strengthening the stabilising muscles of the trunk and the kinetic chains necessary for the triple extension of the lower limbs and arms.

Stage 3 - The goal is to develop the ability to make high and maximum efforts. The highest indices of strength development can now be achieved.

Each sport has its own physiological profile. Therefore, understanding energy systems and how they intervene in sports training is very important for fitness trainers. Energy is the ability to work and is necessary when performing physical activity during training. The body obtains this energy from the breakdown of ATP into ADP + P (phosphate). When this process takes place, energy is released and thus movement occurs. The body can store a limited amount of ATP, so the reserves must be constantly replenished to allow for a longer period of training. The restoration of ATP reserves is achieved by using one of the following three energy systems: anaerobic alactic (ATP-CP) system, anaerobic lactic (glycolytic) system, aerobic system.

The anaerobic alactic system is the main energy source for extremely short explosive actions lasting no longer than 10 seconds such as diving, weight lifting, jumping and athletics events. Muscles can store a small amount of ATP. Because of this, ATP energy stores are rapidly depleted in the first few seconds after the start of a demanding activity and then phosphocreatine (PC) breaks down into creatine (C) and phosphate (P). After the breakdown of phosphocreatine, energy is not released to be used for muscle contraction but to resynthesize adenosine triphosphate (ADP) and phosphate (P) into adenosine triphosphate (ATP).

The anaerobic lactic system is the main energy source for prolonged intense activities (up to about 40 seconds) such as 200 and 400 m sprints and weight training (no more than 40-50 repetitions). The first to provide energy is the ATP-CP system, followed by the anaerobic lactic system after 8-10 seconds. It breaks down muscle and liver glycogen, releasing energy for the resynthesis of ATP from ADP + P. Due to the absence of oxygen during glycogen breakdown, a by-product is formed, namely lactic acid. If high-intensity exercise continues, large amounts of lactic acid build up in the muscles, causing fatigue and ultimately preventing the body from maintaining a high level of intensity.

The aerobic system needs 60 to 80 seconds to produce the energy needed to resynthesize ATP from ADP + P. Unlike other systems, it allows the resynthesis of ATP in the presence of oxygen by breaking down glycogen, lipids and proteins. The aerobic system produces little or no lactic acid, which allows the athlete to continue the effort for a longer period of time (up to 2-3 hours). More than 2-3 hours of aerobic exercise will lead to the use of lipids and proteins in the process of resynthesizing ATP, as glycogen stores are depleted in the body. The breakdown of glycogen, lipids and proteins in the body results in removing carbon dioxide (CO_2) and water (H_2O) from the body through respiration and perspiration as by-products. As aerobic capacity improves, the ability to use lipids as an energy source also improves (Bompa & Buzzichelli, 2019; Osgnach et al., 2010).

Reaching a high level of strength and speed involves exposing the athlete to quality neuromuscular training, which translates into superior neural adaptations (Stasinopoulos & Stasinopoulos, 2017). Neuromuscular training refers to training for maximum speed, power and strength. This type of training increases the efficiency of neural transmissions to the effector muscles but does not necessarily involve an increase in muscle mass. Neuromuscular training improves coordination between muscle groups and maximises the activation and use of fast-twitch muscle fibres involved in strength actions.

When the player performs a quick and powerful action such as hitting the ball over the net by jumping, the neuromuscular system acts as follows:

• at the beginning of the action, phasic (fast-twitch) muscle fibres are mobilised to overcome the force of gravity. The greater the number of phasic fibres used, the easier it will be to overcome the gravitational force that opposes high jumps;

• the initial reactions are followed by increases in acceleration, which impart power and speed to the action that is supported by a higher rate of recruiting phasic fibres to produce contractions. This preliminary increase in the ability of the neuromuscular system to recruit as many phasic fibres as possible is the basis of speed and/or strength sports (Torres-Banduc et al., 2021);

• the increase in strength is achieved by either training with low weights (< 70% 1RM) or performing exercises with the medicine ball. Another way to develop the strength and speed of muscle contractions is plyometric training, which involves a wide variety of jumps. The specificity of this strength training is given by the high execution speeds and short reaction times within a sequence called the stretch-shortening cycle. For example, prior to a net jump or another jump, during the half-squat, a volleyball player accumulates kinetic energy in their muscles and tendons (stretch phase); after the start of the expansion and jump, kinetic energy is released (shortening phase) resulting in an increased activation rate of fast-twitch fibres and consequently a powerful jump;

• strength increases proportionally with maximum strength and is expressed through actions of high speed, rapidity and agility. If strength declines during the competitive season, then speed, rapidity and agility will also decline. Therefore, strength should be maintained throughout the competitive phase (Sarvestan et al., 2018; Toumi et al., 2004).

Strength-endurance is trained by increasing the number of repetitions and sets. Strength-endurance exercises are extremely demanding, which is why they are only designed for athletes who are very well trained in terms of strength (Wagle et al., 2017).

Several studies (Vogt & Hoppeler, 2014; Sheppard et al., 2007; Sheppard et al., 2008) have shown that eccentric muscle contractions improve performance during the concentric phase of stretch-shortening cycles, which is important in sprinting, jumping, throwing and running events. Thus, the eccentric action of muscles is relevant in most sports but especially volleyball. Mike et al. (2017) investigated the effects of eccentric duration contraction on muscle strength, power production, vertical jump and soreness. The research results provide evidence that resistance training with exercises using eccentric contraction can be an effective method to sharply increase maximal strength and power. In addition, "longer eccentric contractions may negatively impact explosive movements such as the vertical jump, whereas shorter eccentric contractions may instigate greater amounts of soreness" (Mike et al., 2017).

On the other hand, specialists such as Córdova-Martínez et al. (2022) have shown that eccentric muscle contractions produce more muscle damage compared to concentric contractions. In this regard, three sports were compared: cycling (mainly concentric), volleyball (mainly eccentric in the legs and concentric in the arms) and basketball (mainly eccentric). The above authors aimed to analyse the pattern of muscle injury blood markers in professional players at two moments of the season: after a training period and after a competitive period. The results showed that, after a training period, muscle damage blood markers were higher in basketball and volleyball players (as expected) due to their dominant eccentric component. However, during competition, these markers were higher in cyclists due to frequent eccentric actions. Therefore, the eccentric-concentric component is not exclusively defined by the sport practised.

The study by Hather et al. (1991) "suggests that optimal muscle hypertrophy in response to resistance exercise is not attained unless eccentric muscle actions are performed. The data also show that heavy resistance exercise may produce muscle fibre transformation and capillary neoformation".

Aspects regarding strength-endurance training

• the scheduling of strength-endurance training is done in the last five weeks of the preparatory stage, just before the start of the championship;

• in the last week before the championship, a low-volume programme (50-60%) will be applied;

• the athletes' fatigue levels are continuously monitored, and the programme is modified if the athletes cannot follow it;

• after each set, athletes must relax the muscles that have been exercised.

Volleyball uses the anaerobic energy system during the active phases and has a strong aerobic basis for recovery and regeneration between competitions. Therefore, a large part of training should be dedicated to improving maximal strength, power and strength-endurance, without neglecting the importance of short- and medium-term muscular endurance (Bompa, 2013). Strength gains are cumulative and require a specific and predictable training sequence. Strength is developed throughout all stages of training during a very important process called periodization.

Periodization is a concept that defines the distribution of maximum power and strength workouts in the training plan over a longer period of time. The purpose of regularising sports training is to schedule specific exercises so that the maximum strength level is reached before the start of the competitive season.

The goal of the adaptation period is to strengthen and prepare the ligaments, tendons and muscles for the next stages where the physical exertion and mechanical stress on these anatomical parts will increase considerably. This period is characterised by high volume and low intensity, and its duration is usually between 4 and 6 weeks, depending on the athlete's history, the length of the transition period and the training performed by the athlete in the transition period.

During the maximum strength period, the aim is to increase the ability of the neuromuscular system to recruit a large number of phasic muscle fibres. The loads used will be between 70% and 95% 1RM, and the training frequency will be 2-3 workouts per week, with an emphasis on eccentric work. The maximum power duration is usually between 3 and 9 weeks, being shorter for beginners and longer for experienced athletes.

The stage of maintaining strength and maximum strength gained in the previous periods covers the entire competitive season. Without such maintenance, apart from maximum strength and power, both speed and agility would decline, and players would not be able to perform at their previous level.

Purpose. The present research aims to develop a physical training programme for volleyball players by using eccentric and concentric exercises to improve strength, but also to observe the morpho-physiological effects of training.

Our approach seeks to identify training programmes that will lead to the improvement of strength/power in volleyball players.

In accordance with the research purpose, the following tasks were established:

- Explosive power assessment using the Optojump analysis and measurement system;
- Anthropometric measurement: thigh circumference;
- Calculation of indices: Flight time (s), Jump height (cm), Speed (s).

Methodology

Participants

The investigated sample included 10 male volleyball players aged 17-26 years, all registered with the CSU Știința Bucharest (a student sports club). They were informed about the testing characteristics and agreed with the way of conducting the experiment, expressing their verbal and written consent.

The research took place between 1 October and 21 December 2021, during the competitive period, and was carried out according to the following scheme: pretest - application of the independent variable (training programme) - posttest.

Research techniques

The anaerobic capacity of junior volleyball players was assessed by two tests measuring:

- Explosive power (Countermovement Jump) using the Optojump analysis and measurement system;
- Jump height;
- Thigh circumference (both left and right thigh).

Test description

Countermouvement jump (CMJ) is used to measure the explosive power of the athlete's lower limbs, being one of the most commonly used tests by coaches and researchers. This test can be performed with or without arm action. Performing the countermouvement jump with the help of arm action has been shown to increase performance by 10% or more, according to some studies (Glatthorn et al., 2011, Becea et al., 2017). Therefore, CMJ is a suitable test for volleyball players, who need high levels of explosive power.

It is important for the test to be performed in a protected environment (gym, laboratory) with a safe surface that is not damp or slippery. If the environment is not optimal, test reliability can lead to worthless data, to inefficiency.

Training programme model

- Monday

- Unilateral plyometrics: 2 series - 6 repetitions
- Power jumps with dumbbells: 2 series - 6 repetitions 30%
- Maximum strength - squats: 2 series - 6 repetitions 70%
- General strength - press - chest - deadlift - femoral biceps - rib cage - abdomen: 2 sets - 10 repetitions

- Tuesday

- Agility - exercise programmes with ladders, cones and hoops: 2-4 sets x 10 repetitions

- Thursday

- Bilateral plyometrics: 2 series - 6 repetitions
- Kneeling power with jump: 2 series - 6 repetitions 50%
- Maximum strength - squats: 2 series - 6 repetitions 75%
- General strength - press - breaking - deadlift - femoral biceps - chest - abdomen: 2 sets - 10 repetitions

- Friday

- Speed - plyometrics - exercise programmes with short-distance standing starts, accelerations, decelerations, stops, starts, medicine ball throwing: 2-4 series - 10 repetitions

The programme was carried out during the competitive period until December, when the final testing took place.

Equipment

For the good conduct of the tests and a more accurate data collection, we checked the proper functioning of the Optojump computerised analysis system.

Optojump is an optical measurement system that consists of a transmission and reception bar, with each one containing 96 LEDs (1.0416 cm resolution). The LEDs on the transmission bar constantly communicate with those on the reception bar. The system detects any interruptions in communication between the bars and calculates their duration. This makes it possible to measure flight and contact times during a series of jumps with an accuracy of 1/1000 of a second. Based on this fundamental data, the dedicated software makes it possible to obtain several parameters connected to the athlete's performance with maximum accuracy and in real time. (Microgate, 2014)

Testing procedure

• Arm swing: The teacher/coach must decide before testing whether to include or eliminate the use of arm swing, because it is important to understand that arm swing can improve performance by 10% or even more (Shetty & Etnyre, 1989). If the arm swing is not allowed, then athletes must keep their hands on their hips throughout the test. In this case, the teacher/coach should also pay close attention to the athlete's hands to ensure that they are not using them to press additional force through the legs (Walker, 2016). In this test, athletes used arm raises.

• During flight: While in the air, it is essential for athletes to maintain extension in the hip, knee and ankle joints to prevent any additional flight time by bending their legs (Markovic et al., 2004; Glatthorn et al., 2011).

• Jump displacement: It is important for the athlete to jump as high as possible and try to land in the same location as they took off because jumping forwards, backwards or sideways can affect the test results. To avoid this, the area was marked on the floor (Figure 1). (Walker, 2016)

The athletes performed two jumps, and the best was recorded.

As the data are saved, it is possible to view them at any time. It is also possible to compare the performance of different athletes or the same athlete at different times.

Figure 1. Optojump – CMJ (Microgate, 2014)

Results

Through this study, we wanted to determine whether there were significant differences between the initial and final testing at the end of the experimental intervention, after applying action systems based on the means of volleyball in order to improve performance. Statistically processed data for volleyball-specific motor tests indicate an improvement in both technical execution time and precision of throwing over the net. Thus, the mean difference for Jump height is 4.22 units, which is statistically significant according to Student's test: t = 3.49, p = 0.0006 (Table 1, Figure 2). The Cohen's index value (0.40) shows that there is an average difference between the arithmetic means corresponding to the two tests.

Table 1. *Statistical data for Jump height*

Statistical tests	**Jump height Initial test**	**Jump height Final test**
Mean (x)	39.72	43.94
Standard deviation	3.33	3.05
Maximum	41.80	48.30
Minimum	35.70	38.00
Coefficient of variation	0.083	0.069
Student's test	t = 3.4964	p = 0.006

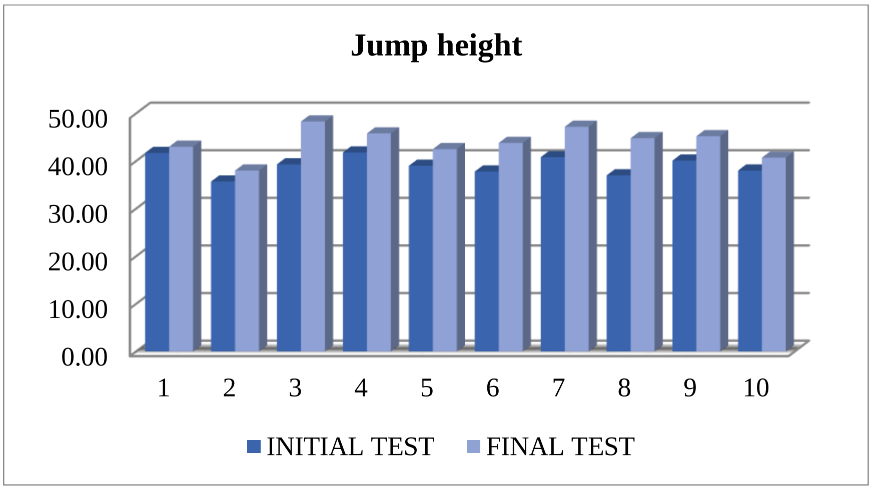

Figure 2. Average scores for Jump height

Between the two tests, the results for Countermovement jump (J/Kg) indicate a statistically significant increase of 0.54 units, according to Student's test: t = 6.554, p = 0.0001 (Table 2, Figure 3). The Cohen's index value (0.56) shows that there is an average difference between the arithmetic means corresponding to the two tests.

Table 2. *Statistical data for Power (J/Kg)*

Statistical tests	**Power J/Kg Initial test**	**Power J/Kg Final test**
Mean (x)	3.80	4.34
Standard deviation	0.2093	0.3192
Maximum	4.25	4.75
Minimum	3.51	3.64
Coefficient of variation	0.055	0.0072
Student's test	t = 6.5549	p = 0.0001

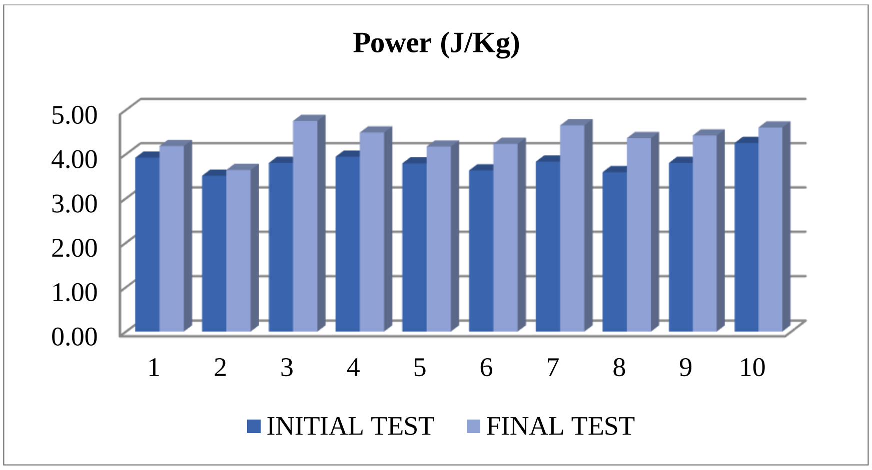

Figure 3. Average scores for Countermovement jump (J/Kg)

Between the two tests, the results for Thigh circumference indicate a decrease of 0.77 units for the right thigh, which is statistically significant according to Student's test: t = 3.1549, p = 0.0116, and a decrease of 1.15 units for the left thigh, which is statistically significant according to Student's test: t = 5.4380, p = 0.0004 (Table 3, Figure 4). The Cohen's index value (0.43) shows that there is an average difference between the arithmetic means corresponding to the two tests.

Table 3. *Statistical data for Thigh circumference*

Statistical tests	**Right thigh circumference**		**Left thigh circumference**	
	Initial test	**Final test**	**Initial test**	**Final test**
Mean (x)	53.40	54.17	51.55	52.70
Standard deviation	3.40	3.56	3.70	4.00
Maximum	58	59	56.5	58.00
Minimum	48	48.5	45	46
Coefficient of variation	0.063	0.065	0.071	0.075
Student's test	t = 3.1549 p = 0.0116		t = 5.4380 p = 0.0004	

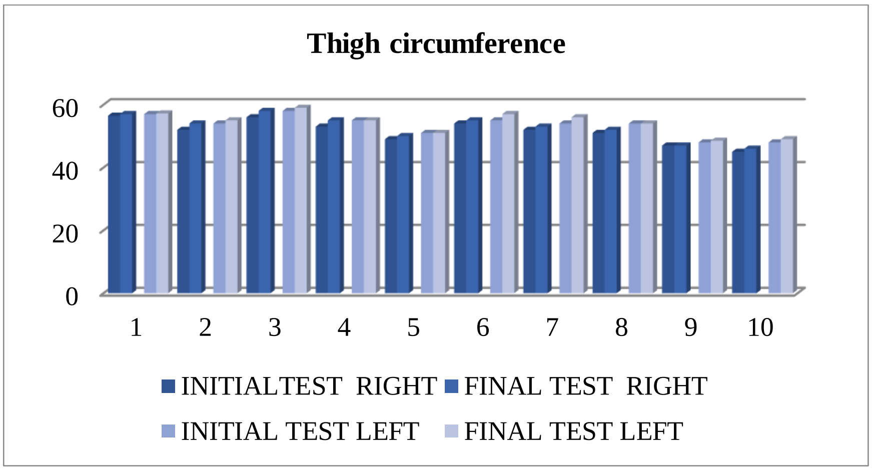

Figure 4. Average scores for Thigh circumference

Discussion and Conclusion

The theoretical analysis and generalisation of the experimental data allowed establishing the effective influence of the eccentric/concentric training method on the development of lower limb strength after applying the intervention programmes to the investigated athletes.

According to existing studies in the literature (Seger et al., 1998), the implementation of eccentric/concentric training methods contributes to developing strength and motor skills in volleyball players. "Therefore, including plyometric training in the preparatory period for volleyball, with low monotony and training strain increment, is an effective strategy for further CMJ performance improvement." (Guimarães et al., 2022)

The research results highlight the role and importance of implementing strength and maximum strength development programmes in the physical training of volleyball players for achieving the best performance. The training plan applied and accepted by athletes has proven to be viable and effective, which is supported by each athlete's score achieved in the final testing and the fulfilment of the objective assumed at the beginning of the championship.

The obtained results clearly show that the training of each athlete needs to be done with means and methods that mainly develop the required qualities in the muscle groups engaged in exercise during the specific volleyball training. Training for sports performance should aim at constantly increasing exercise capacity in order to develop the best possible adaptation to the workload and maintain exercise intensity for as long as possible.

Due to the independent variable applied during the training programme, the final testing has demonstrated the definite progress made by each athlete, and the obtained results can be considered as a direction to be implemented in the training programme of volleyball teams.

This information could help sports professionals plan specific training programmes, preparation for competition and recovery after training.

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References

Becea, L., Pelin, R. A., Rachita, I., & Branet, C. (2017). A comparative study on the indirect assessment of leg extensor power using simultaneously the Jump-and-Reach Test from Alpha-Fit and the Optojump system. In I. Roceanu (Ed.), *Proceedings of the 13th*

International Scientific Conference eLearning and Software for Education (Vol. 3, pp. 154-160). "Carol I" National Defence University. DOI: 10.12753/2066-026X-17-196

Bompa, T. O. (2013). *Antrenamentul pentru sporturile de echipă* [Training for team sports]. Centrul Național de Formare și Perfectionare a Antrenorilor.

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

Córdova-Martínez, A., Caballero-García, A., Bello, H. J., Perez-Valdecantos, D., & Roche, E. (2022). Effects of eccentric vs. concentric sports on blood muscular damage markers in male professional players. *Biology*, *11*(3): 343. https://doi.org/10.3390/biology11030343

Glatthorn, J. F., Gouge, S., Nussbaumer, S., Stauffacher, S., Impellizzeri, F. M., & Maffiuletti, N. A. (2011). Validity and reliability of Optojump photoelectric cells for estimating vertical jump height. *The Journal of Strength & Conditioning Research*, *25*(2), 556-560. https://doi.org/10.1519/jsc.0b013e3181ccb18d

Guimarães, M. P., Silva, R. D., Dos Santos, I. A., Da Silva, G. P., Campos, Y. A., Da Silva, S. F., & De Azevedo, P. H. S. M. (2022). Effect of 4 weeks of plyometric training in the pre-competitive period on volleyball athletes' performance. *Biology of Sport*, *40*(1), 193-200. https://doi.org/10.5114/biolsport.2023.112971

Hather, B. M., Tesch, P. A., Buchanan, P., & Dudley, G. A. (1991). Influence of eccentric actions on skeletal muscle adaptations to resistance training. *Acta Physiologica Scandinavica*, *143*(2), 177-185. https://doi.org/10.1111/j.1748-1716.1991.tb09219.x

Markovic, G., Dizdar, D., Jukic, I., & Cardinale, M. (2004). Reliability and factorial validity of squat and countermovement jump tests. *The Journal of Strength and Conditioning Research*, *18*(3), 551-555. https://doi.org/10.1519/1533-4287(2004)18%3C551:rafvos%3E2.0.co;2

Microgate. (2014). *Optojump Next*. http://www.optojump.com/what-is-optojump.aspx

Mike, J. N., Cole, N., Herrera, C., VanDusseldorp, T., Kravitz, L., & Kerksick, C. M. (2017). The effects of eccentric contraction duration on muscle strength, power production, vertical jump, and soreness. *The Journal of Strength and Conditioning Research*, *31*(3), 773-786. https://doi.org/10.1519/JSC.0000000000001675

Osgnach, C., Poser, S., Bernardini, R., Rihaldo, R., & di Prampero, P. E. (2010). Energy cost and metabolic power in elite soccer: New match analysis approach. *Medicine & Science in Sports & Exercise*, *42*(1), 170-178. https://doi.org/10.1249/mss.0b013e3181ae5cfd

Sarvestan, J., Cheraghi, M., Sebyani, M., Shirzad, E., & Svoboda, Z. (2018). Relationships between force-time curve variables and jump height during countermovement jumps in young elite volleyball players. *Acta Gymnica*, *48*(1), 9-14. http://dx.doi.org/10.5507/ag.2018.003

Seger, J. Y., Arvidsson, B., Thorstensson, A., & Seger, J. Y. (1998). Specific effects of eccentric and concentric training on muscle strength and morphology in humans. *European Journal of Applied Physiology and Occupational Physiology*, *79*(1), 49-57. https://doi.org/10.1007/s004210050472

Sheppard, J., Newton, R., & McGuigan, M. (2007). The effect of accentuated eccentric load on jump kinetics in high-performance volleyball players. *International Journal of Sports Science & Coaching*, *2*(3), 267-273. https://doi.org/10.1260/174795407782233209

Sheppard, J., Hobson, S., Barker, M., Taylor, K., Chapman, D., McGuigan, M., & Newton, R. (2008). The effect of training with accentuated eccentric load counter-movement jumps on strength and power characteristics of high-performance volleyball players. *International Journal of Sports Science & Coaching*, *3*(3), 355-363. https://doi.org/10.1260/174795408786238498

Shetty, A. B., & Etnyre, B. R. (1989). Contribution of arm movement to the force components of a maximum vertical jump. *Journal of Orthopaedic and Sports Therapy, 11*, 198-201. https://doi.org/10.2519/jospt.1989.11.5.198

Stasinopoulos, D., & Stasinopoulos, I. (2017). Comparison of effects of eccentric training, eccentric-concentric training, and eccentric-concentric training combined with isometric contraction in the treatment of lateral elbow tendinopathy. *Journal of Hand Therapy, 30*(1), 13-19. https://doi.org/10.1016/j.jht.2016.09.001

Taware, G. B., Bhutkar, M. V., & Surdi, A. D. (2013). A profile of fitness parameters and performance of volleyball players. *Journal of Krishna Institute of Medical Sciences University, 2*(2), 48-59.

Torres-Banduc, M., Ramirez-Campillo, R., Andrade, D. C., Calleja-González, J., Nikolaidis, P. T., McMahon, J. J., & Comfort, P. (2021). Kinematic and neuromuscular measures of intensity during drop jumps in female volleyball players. *Frontiers in Psychology, 12*: 724070. https://doi.org/10.3389/fpsyg.2021.724070

Toumi, H., Best, T. M., Martin, A., F'Guyer, S., & Poumarat, G. (2004). Effects of eccentric phase velocity of plyometric training on the vertical jump. *International Journal of Sports Medicine, 25*(5), 391-398. https://doi.org/10.1055/s-2004-815843

Vogt, M., & Hoppeler, H. H. (2014). Eccentric exercise: Mechanisms and effects when used as training regime or training adjunct. *Journal of Applied Physiology*, *116*(11), 1446-1454. https://doi.org/10.1152/japplphysiol.00146.2013

Wagle, J. P., Taber, C. B., Cunanan, A. J., Bingham, G. E., Carroll, K. M., DeWeese, B. H., Sato, K., & Stone, M. H. (2017). Accentuated eccentric loading for training and performance: A review. *Sports Medicine*, *47*(12), 2473-2495. https://doi.org/10.1007/s40279-017-0755-6

Walker, O. (2016). *Countermovement jump (CMJ)*. https://www.scienceforsport.com/countermovement-jump-cmj/