



EFFECT OF 8 WEEKS OF COMBINED PLYOMETRIC TRAINING ON INCREASING LOWER AND UPPER BODY MUSCLE POWER IN STUDENT VOLLEYBALL ATHLETES

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Abstract

The study purpose was to identify the effects of a combination of plyometric exercises in the increasing leg and arm power abilities of volleyball athletes.

Materials and methods. Forty students were involved in this study. They were students who were active in practicing volleyball, and then they were divided into four groups of 10 students each, namely (1) Squat thrust jumps and clap push-ups, (2) Squat thrust jumps and lateral push-ups, (3) Rope jumps and clap push-ups; and (4) Rope jumps and lateral push-ups. Then they practiced plyometrics three times a week for eight weeks. Statistical analysis used the t-test and the N-Gain Score using the Statistical Package for Social Science (SPSS) version 26 program.

Results. The results of the combination of plyometric exercises stated that it had an effect on the muscle power of both the legs and arms ($p < 0.05$); then, the results showed the combination of squat thrust and lateral push-up exercises was effective in increasing the ability of leg muscle power by 84.43% while the variety of squat thrust jump exercises and clap push-ups provide effectiveness in increasing arm muscle power by 25.23%.

Conclusions. The variety of these two types of plyometric exercises was successful in helping volleyball athletes improve their vertical jump abilities. Still, from the results of this study, it was not very effective in increasing the capacity of arm muscle power.

Keywords: plyometrics, power, muscles, combined exercises.

Introduction

Volleyball is a very popular sport at this time, to become a professional player, it requires main indicators on anthropometric profiles (height and BMI) as well as physical components (leg power, speed, and agility) (Tsoukos et al., 2019), volleyball athletes also need development of explosive power exercises to support performance (Loturco et al., 2018). Athletes with low levels of performance differ significantly, with athletes from higher-ranked teams achieving better results (Pocek et al., 2021). Successful players are volleyball athletes with slimmer and taller anthropometric profiles and greater motor skills than lower-level players (Milić et al., 2017). Volleyball coaches must be observant in developing these two profiles from the start of the athlete joining the training program.

Success in attacking actions in volleyball matches is directly related to the athlete's ability to make vertical jumps (Berriel et al., 2021). Thus, players need coordinated movements of the hips, torso, shoulders, elbows, and wrist muscles to efficiently transfer their power to the ball (Baena-Raya et al., 2021). Therefore, volleyball athletes often perform jumps, moving quickly, and a combination of the two during practice and matches.

Improved spike performance is generally associated with increased motor mobilization units, increased coordination between muscles, increased nerve stimulation to agonist muscles, and increased use of SSCs (Markovic & Mikulic, 2010; Taube et al., 2012). Plyometric exercises show positive things for volleyball athletes, and practices are characterized by slow cycles of muscle-tendon shortening (SSC) or fast SSC and jumping exercises with different ground contact times (Ramirez-Campillo et al., 2020). During slow and fast SSC, the accumulation of elastic energy facilitates greater

regeneration of mechanical work, i.e., explosive forces in subsequent actions (Radnor et al., 2017).

Plyometric training is suitable for increasing vertical jumping ability (Stojanović et al., 2017), agility, and speed (Silva et al., 2019). All of these components are needed by volleyball athletes. In addition, plyometric training, combined with other typical training modalities, elicits many positive changes in healthy individuals' nervous and musculoskeletal systems, muscle function, and athletic performance (Markovic & Mikulic, 2010). In previous research, plyometric training can increase the jumping ability of young athletes (Meylan & Davide, 2009; Santos & Janeira, 2008); squat thrust and jumping rope are types of exercises that can increase speed and power (Fischetti et al., 2018).

In addition to strengthening the lower muscles, volleyball players also need to increase performance in the upper body, especially in the trapezius and pectoralis muscles (Cuckova et al., 2012). Clap push-up exercise is an exercise that can increase the activation ability of the pectoralis major, triceps brachii, and anterior deltoid muscles (Nadzalan et al., 2021). This type of plyometric exercise is highly recommended to increase strength in the upper body (Moore et al., 2011).

Many reviews have been written about the benefits of plyometric training. However, most of these reviews focus on one body part (Sole et al., 2021). This study focuses on the effect of 2 plyometric combination exercises on increasing body performance in the arms and legs. Both of these parts have contributed to the implementation of volleyball athletes in volleyball.

Materials and methods

Participants

Forty male students participated in this study. They have inclusion requirements, namely 1. Are students who are active in the activities of the volleyball branch student activity unit. 2. The age of the participants is 19-20 years. 3. Actively engage in physical activity at least three times a week. Furthermore, 40 students were divided into four experimental groups, which were differentiated based on the form of exercise given. The division is group (1) Squat thrust jump and clap push-ups; (2) squat thrust jumps and lateral push-ups, (3) rope jumps and clap push-ups; and (4) Rope jumps and lateral push-ups. Before the trial, participants were informed of the benefits and potential risks associated with the study. In addition, all signed informed consent forms according to the most recent revision of the Declaration of Helsinki.

Table 1. Demographic Characteristics

N	Body Weight	Body Height	Age
40	60-70 kg	170-180 cm	19-20 Years

Study Protocol

Forty participants will carry out combined plyometric physical training for 8 weeks (3 times a week) (Negra et al., 2020; Voisin & Scohier, 2019). All participants were divided into four groups, and each group had 10 participants; they were included in groups (1) Squat thrust jumps and clap

push-ups, (2) squat thrust jump and lateral push up, (3) rope jump and clap push up; and (4) Rope jumps and lateral push-ups. Leg power was assessed using a force plate/Accu power version 1.3, and arm power was measured using a ball medicine throw test.

Statistical analysis

The mean and standard deviation were measured using descriptive statistics. Furthermore, to determine the differences in each treatment using the t-test. And to see what treatment is most effective in supporting the performance of power for both resolution and arm muscles, the NGain Score test is used. Statistical analyzes were performed using the SPSS 26 program for Windows (SPSS, Inc., Chicago, IL).

Results

Table 2 explains that the four groups provide differences after doing a combination of plyometric exercises. Squat thrust exercise gives the best results in increasing leg and arm muscle power after undergoing plyometric training for eight weeks.

Table 2. Results of Descriptive Analysis of the difference between Pre-test and post-test Power of the Muscles of the Legs and Arms

Group Treatment	N	Leg Muscle		Arm Muscle	
		Mean (Watt)	SD	Mean (Meter)	SD
Squat thrust and clap push up	10	10.10	2.60	9.92	2.70
Squat thrust and lateral push up	10	6.44	0.72	7.29	1.27
Rope jump and clap push up	10	10.02	1.70	5.06	1.92
Rope jump and lateral push up	10	5.35	1.46	5.65	2.50

Table 3 shows that the intervention of squat thrust and lateral push-up exercises gave a highly practical value of 84.43% in increasing leg muscle ability. Furthermore, the intervention of squat thrust and clay push-up exercises only provided an effective value of 45.53%. On the other hand, the combination of rope jump and lateral push-up exercises only gives a weight of 3.36%. Meanwhile, the variety of rope jump and lateral push-up exercises gave a small value of 3.36%, or it can be said that it was ineffective for leg power.

In table 4, it can be seen that the intervention of several combinations of plyometric exercises only had an impact of less than 25% on increasing the performance of arm muscle power. First, the variety of plyometric exercises in the form of squat thrusts and clap push-ups has the greatest impact, with an effect of 25.23%. Then, the combination of plyometric exercises in the form of squat thrusts and lateral push-ups has an effect of 21.66%. After that, the variety of plyometric exercises in rope jumps and clap push-ups only had an effect of 14.83%. And the combination of plyometric exercises in the form of rope jumps and lateral push-ups only had an impact of 22.18% on arm power ability.

Table 3. Of the effectiveness of the exercise on the four treatments on leg muscle power

No	Group Treatment	N	r	t	Sig.	N-Gain Score	%
1	Squat thrust and clap push up	10				45.53	45.53 %
2	Squat thrust and lateral push up	10	0.641	-6.381	0.000	84.43	84.43 %
3	Rope jump and clap push up	10				3.36	3.36 %
4	Rope jump and lateral push up	10				15.36	15.36 %

Table 4. Shows the effectiveness of exercise in 4 treatments on arm muscle power

No	Group Treatment	N	r	t	Sig.	N-Gain Score	%
1	Squat thrust and clap push up	10				-25.23	25.23 %
2	Squat thrust and lateral push up	10	0.991	-15.662	0.000	-21.66	21.66 %
3	Rope jump and clap push up	10				-14.83	14.83 %
4	Rope jump and lateral push up	10				-22.18	22.18 %

Discussion

Volleyball has immediate difference from similar sports such as basketball. This sport allows an athlete to perform explosive power in both the lower body (legs) and upper body (arms). This happens when a volleyball player hits a mass, and then the function of the leg and arm muscles both perform explosive power movements. In volleyball, the ability to jump on each player is very important to master because it is a characteristic of the volleyball game itself, especially in increasing improvement and maintaining points (Pereira et al., 2015).

After eight weeks of plyometric training with a combination of plyometric exercises, it was found that the variety of plyometric exercises using squat thrusts had more impact on the average power of volleyball athletes than the group using a variety of rope jump plyometric exercises. However, the squat thrust combination group and the rope jump combination gave the same results.

Hypertrophy of the quadriceps, Vastii, rectus femur and gluteus maximus muscles is why there is an increase in power in the supporting muscles (Ribeiro et al., 2022). In addition, squat thrust exercises also increased the quality of the vertical jump both in the single plyometric exercise group (Ramlan et al., 2018) and in combination with plyometric training (Adams et al., 1992).

This study found that plyometric exercise more effectively influenced lower body power. This is in line with previous research, which concluded that plyometric training has the potential to improve lower extremity performance (Chelly et al., 2014; Davies et al., 2015; Hrzenjak et al., 2016). Therefore, plyometric training is an important component of any training program for volleyball players (Ahmadi et al., 2021).

Two volleyball players' abilities, such as spike and block, rely heavily on jumping skills. Fast and high jumps are an important requirement for every player (Loturco et al., 2017). The increased elastic characteristics of musculotendinous nerves are thought to cause increased muscle performance when jumping (Ignjatovic et al., 2012). Plyometric training can lead to neuromuscular adaptations that lead to improved jumping performance. These adaptations can include increased nerve impulses to the agonist's muscle, changes in the mechanical stiffness characteristic of muscle-tendon,

changes in muscle size and/or architecture, and changes in single-fibre mechanics (de Villarreal et al., 2009; Maffiuletti et al., 2002; Thomas et al., 2009). Other possible aspects of neural adaptation to plyometric training include changes in leg muscle activation strategy (or inter-muscle coordination) during vertical jumps, particularly during the preparatory jump phase (i.e., pre-landing), and (ii) changes in the excitability of the stretch reflex (Bishop & Spencer, 2004; de Villarreal et al., 2009).

The interesting thing in this study was that the rope jump exercise treatment group did not show effectiveness in the power test results for both leg and arm muscles. This is possible because rope jump training tends to give great value to increasing agility and speed skills (Fischetti et al., 2018).

The surprising finding in this study was that the percentage of exercise effectiveness in the group did not give effective results when associated with the performance of arm muscle power. In this study, the four treatments had less than 25% practical value, so they were considered ineffective in increasing arm muscle power. In addition, clap push-ups in the study (Moore et al., 2011) gave differences from the results of the pre and post-tests in this study also made differences. Still, in the statistical analysis results, the N-Gain score had a low effectiveness value.

Research provides a new understanding of training patterns to increase power in volleyball athletes. Combining the two exercises to increase power in the upper body (arm muscles) and upper body (leg muscles) is only effective in one component, the upper body.

Conclusions

The combination of 2 types of plyometric exercises greatly impacts increasing power in the leg muscles. The variety of these two types of plyometric exercises was successful in helping volleyball athletes improve their vertical jump abilities. Still, from the results of this study, it was not very effective in increasing the capacity of arm muscle power.

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ВПЛИВ 8 ТИЖНІВ КОМБІНОВАНОГО ПЛІОМЕТРИЧНОГО ТРЕНУВАННЯ НА ЗБІЛЬШЕННЯ СИЛИ М'ЯЗІВ НИЖНЬОЇ ТА ВЕРХНЬОЇ ЧАСТИНИ ТІЛА У СТУДЕНТІВ-ВОЛЕЙБОЛІСТІВ

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

Реферат. Стаття: 6 с., 4 табл., 35 джерел.

Метою дослідження було виявити вплив комбінації пліометричних вправ на збільшення силових здібностей ніг і рук у волейболістів.

Матеріали та методи. У цьому дослідженні брали участь сорок студентів. Це були студенти, які активно займалися волейболом, їх розділили на чотири групи по 10 студентів у кожній, а саме: (1) стрибки з присіду ногами назад у положення планки й поверненням у вихідне положення зі стрибком у висоту та віджимання з оплесками, (2) стрибки з присіду ногами назад у положення планки й поверненням у вихідне положення зі стрибком у висоту та бокові віджимання, (3) стрибки зі скакалкою та віджимання з хлопками; та (4) стрибки зі скакалкою та бокові віджимання. Потім вони займалися пліометрією тричі на тиждень протягом восьми тижнів. Для статистичного аналізу використовували t-критерій Стьюдента та оцінку нормалізованого приросту за допомогою ПЗ Statistical Package for Social Science (SPSS) версії 26.

Результати. Результати комбінації пліометричних вправ свідчать про її вплив на силу м'язів як ніг, так і рук ($p < 0,05$); також, результати показали, що комбінація вправ «стрибки з присіду ногами назад у положення планки й поверненням у вихідне положення зі стрибком у висоту» та «бокові віджимання» була ефективною для збільшення здатності сили м'язів ніг на 84,43%, тоді як різноманітність вправ на стрибки з присіду ногами назад у положення планки й поверненням у ви-

хідне положення зі стрибком у висоту та віджимання з оплесками забезпечує ефективність у збільшенні сили м'язів рук на 25,23%.

Висновки. Різноманітність цих двох типів пліометричних вправ успішно допомогла волейболістам покращити їхні здібності у виконанні стрибків у висоту. Проте, за результатами цього дослідження, вона не була дуже ефективною у збільшенні сили м'язів рук.

Ключові слова: пліометрія, сила, м'язи, комбіновані вправи.

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