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

POSITIVE EFFECTS OF PLYOMETRIC TRAINING ON INCREASING SPEED, STRENGTH AND LIMB MUSCLES POWER IN ADOLESCENT MALES

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

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Accepted for Publication: January 3, 2023
Published: February 28, 2023

DOI: 10.17309/tmfv.2023.1.06

Abstract

The study purpose was to prove the effectiveness of a plyometric jumping jack, countermovement jump, and tuck jump training in increasing speed, strength, and limb muscle power in adolescent males.

Materials and methods. A total of 33 subjects from Santri Pondok Pesantren An-Nur 2 Al-Murtadlo Malang Regency, males, aged 18-22 years voluntarily participated in the study. The subjects were divided into 3 intervention groups, namely PJJ (n = 11, plyometric – jumping jacks), PCJ (n = 11, plyometric – countermovement jump), and PTJ (n = 11, plyometric – tuck jump). Plyometric jumping jacks, countermovement jump, and tuck jump training was conducted for 30 minutes/session, intensity 70-90% 1-RM, frequency 3x/week for 6 weeks. Measuring limb muscle power used the Jump Meter Digital (MD) Test, measuring limb muscle strength used the Back & Leg Dynamometer, and measuring speed used the 30 m running test. The data analysis technique used the Paired Sample T-Test with a significance level of 5%.

Results. The results obtained were as follows: mean speed between pretest and posttest on PJJ (4.56±0.16 vs. 4.36±0.15 second, ($p \leq 0.001$)), PCJ (4.61±0.15 vs. 4.54±0.14 second, ($p \leq 0.001$)), PTJ (4.55±0.19 vs. 4.48±0.18 second, ($p \leq 0.001$)), limb muscle strength between pretest and posttest in PJJ (111.45±18.94 vs. 139.27±20.23 kg, ($p \leq 0.001$)), PCJ (117.73±21.03 vs. 129.55±19.24 kg, ($p \leq 0.001$)), PTJ (115.46±17.66 vs. 125.91±18.62 kg, ($p \leq 0.001$)), limb muscle power between pretest and posttest in PJJ (422.86±34.61 vs. 493.12±49.24 joule, ($p \leq 0.001$)), PCJ (410.70±38.25 vs. 462.20±38.55 joule, ($p \leq 0.001$)), PTJ (404.20±45.63 vs. 441.78±46.90 joule, ($p \leq 0.001$)).

Conclusions. Based on the results of the study, it was concluded that plyometric jumping jacks, countermovement jumps, and tuck jumps performed for 30 minutes/session, with an intensity of 70-90% 1-RM, frequency 3x/week for 6 weeks are effective in increasing limb muscle power, strength and speed.

Keywords: plyometric training, speed, limb muscle strength, limb muscle power.

Introduction

Plyometrics is one type of strength training that is widely used in team and individual sports to improve sports performance (Ramírez-delaCruz, et al., 2022; Davies et al., 2015; Sammoud et al., 2019). Plyometrics involves multi-joint movements (i.e., jumping, jumping, jumping) that utilize a stretch-shortening cycle, where muscles are rapidly stretched (eccentric phase) and then immediately shortened (concentric phase) (Marzouki et al., 2022; Ramirez- Campillo et al., 2018; Granacher et al., 2015). Plyometrics can improve motor skills and body composition, such as optimizing bone health and reducing fat mass when combined with a daily training routine (Wang & Zhang, 2016).

To achieve good health conditions and good performance in sports, having the good physical condition is a major component (Malm et al., 2019). Physical condition is the basis for achieving optimal skills (Adams et al., 2018). Without good physical condition, it will be difficult to carry

out an training program and attain skills. Physical condition is one of the requirements to achieve achievement. Limb muscles are an integral part of generating strength, so they are an important component for athletes to express high levels of strength in dynamic movements (power = Force velocity) (Falch et al., 2022; Haff & Stone, 2015).

Strength training can induce neuromuscular adaptation, with increased sprint, and agility, in both adolescents and adults (Hammami et al., 2018; Brito et al., 2014; Keiner et al., 2014). Plyometric training usually involve stopping, starting, and changing direction explosively. This movement is a component that can help in developing agility (Miller et al. 2006; Craig 2004; Miller et al., 2001). Several studies have confirmed that plyometrics can improve muscle strength and power, speed, and agility (Slimani et al., 2016; Ramírez-Campillo et al., 2015; Michailidis et al., 2013). Therefore, this study aims to prove the effectiveness of a plyometric jumping jack, countermovement jump, and tuck jump training in increasing speed, strength, and limb muscle power in adolescent males.

Materials and Methods

Research design

This research is a quasi-experimental research design with factorial designs. A total of 33 Santri Pondok Pesantren An-Nur 2 Al-Murtadlo Malang Regency, males, aged 18-22 years, have a normal body mass index (19-24 kg/m^2), blood pressure (systolic and diastolic) normal (110/70-120/80 mmHg), normal resting heart rate (60-80 bpm), normal oxygen saturation (SpO_2)(95-100%) voluntarily participated in the study. Subjects were divided into 3 intervention groups, namely PJJ (n = 11, plyometric – jumping jacks), PCJ (n = 11, plyometric – countermovement jump), and PTJ (n = 11, plyometric – tuck jump). Our research protocol complies with the Helsinki World Medical Association Declaration on the ethical conduct of research involving human subjects.

Study participants

Plyometric jumping jacks, countermovement jump, and tuck jump training are conducted for 30 minutes/session, intensity 70-90% 1-RM, frequency 3x/week for 6 weeks, so the total training is 18 meetings. Warming up and cooling down are each carried out for 5 minutes with an intensity of 50-60% HRmax (Sugiharto et al., 2022; Rejeki et al., 2022). Heart rate monitoring during training using a polar heart rate monitor (Polar H10 Bluetooth Heart Rate Sensor & Fitness Tracker, Polar, Kempele, Finland) (Andarianto et al., 2022).

The data collection process was carried out by taking anthropometric measurements which included height using a Stadiometer (Seca Corporation, CHINO, California, USA) (Rejeki et al., 2021), body weight using a digital scale (OMRON HN-289, Osaka, JAPAN) (Sugiharto et al., 2022). The calculation of body mass index (BMI) uses the formula of body weight (kg) divided by height (m^2) (Raharjo et al., 2021). Blood pressure (systolic and diastolic) was measured using an OMRON Deluxe Model HEM-8712 BASIC digital blood pressure meter (Puspodari et al., 2022). Measurement of limb muscle power using the Jump Meter Digital (MD) Test, measuring limb muscle strength using the Back & Leg Dynamometer, and measuring speed using the 30 m running test. Measurements of speed, strength, and limb muscle power were carried out before the intervention and after the last intervention for 6 weeks.

Statistical Analysis

The data analysis technique used the Statistical Package for Social Science (SPSS) version 23 software. The normality test used the Shapiro-Wilk test, while the homogeneity test used the Levene Test. Different tests using Paired Sample T-Test and One-way ANOVA then followed by Least Significant Difference (LSD) post-hoc test. All statistical analyzes used a significant level of 5%. All data displayed Mean ± Standard Deviation (SD).

Results

Based on the results of the One-way ANOVA analysis showed that there was no significant difference in the characteristics of the subjects between groups ($p \geq 0.05$). The results of the analysis of the average speed, strength, and limb muscle power between pretest and posttest in each group is shown in Figure 1-3 below.

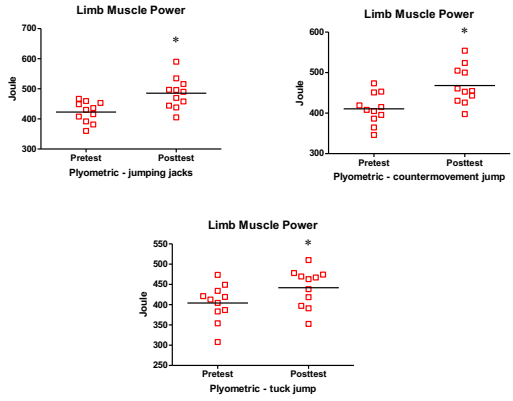

Fig. 1. The results of the analysis of the average limb muscle power between the pretest and posttest in the three groups. Description: (*) Significantly different from the pretest ($p \leq 0.001$). Presentation of data with mean±SD. p-value obtained by analysis of Paired Sample T-Test.

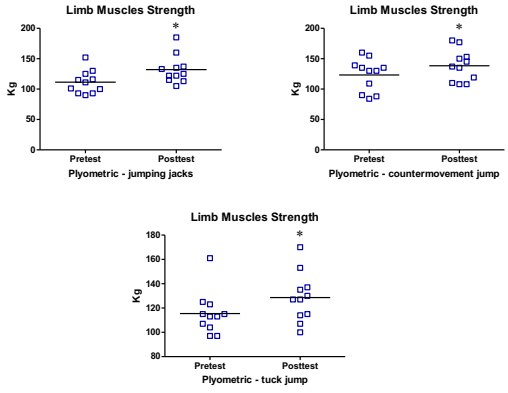

Fig. 2. The results of the analysis of the average limb muscle strength between the pretest and posttest in the three groups. Description: (*) Significantly different from the pretest ($p \leq 0.001$). Presentation of data with mean±SD. p-value obtained by analysis of Paired Sample T-Test.

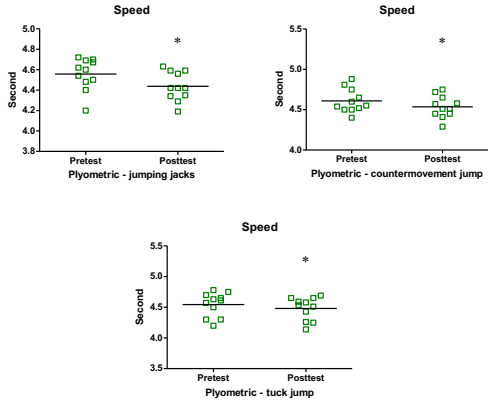

Fig. 3. The results of the analysis of the average speed between the pretest and posttest in the three groups. Description: (*) Significantly different from the pretest ($p \leq 0.001$). Presentation of data with mean±SD. p-value obtained by analysis of Paired Sample T-Test.

Based on the results of the Pearson's Correlation Coefficient Test analysis in Figure 4 shows a strong correlation between limb muscle power and limb muscle strength (r = 0.552, p-value=0.001) and speed (r = 0.516, p-value=0.001) with a positive correlation direction.

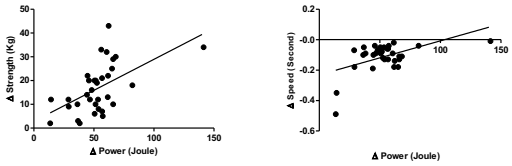

Fig. 4. Results of correlation analysis between limb muscle power with limb muscle strength and speed. Description: p-value was obtained by pearson's correlation coefficient test ($p \leq 0.001$).

Discussion

This study aims to prove the effectiveness of a plyometric jumping jack, countermovement jump, and tuck jump training on increasing speed, strength, and limb muscle power in adolescent males. Based on the results of the study, it was found that there was a significant increase in the level of speed, strength, and limb muscle power after plyometric jumping jack, countermovement jump, and tuck jump training. These results are in line with the results of the meta-analysis by Ramirez-Campillo et al. (2022) revealed a significant effect of plyometric training on increasing muscle mass, total limb muscle volume, thigh muscle volume, thigh circumference, calf circumference, and muscle pennation angle without intervention-related side effects and injuries. Results by Kim

Table 1. The characteristics of research subjects

Parameter	PJJ (*n* = 11)	PCJ (*n* = 11)	PTJ (*n* = 11)	*p*-value
Age (yrs)	19.64±1.12	19.73±1.11	19.55±1.04	0.926
Body height (m)	1.66±0.05	1.64±0.03	1.65±0.06	0.395
Body weight (kg)	58.73±6.69	57.36±5.12	57.27±3.58	0.772
Body mass index (kg/m^2)	21.19±1.37	21.43±1.65	20.85±0.73	0.582
Systolic blood pressure (mmHg)	115.64±3.56	114.36±7.71	115.55±4.37	0.834
Diastolic blood pressure (mmHg)	75.82±3.43	75.45±4.55	75.00±4.56	0.901
Resting heart rate (bpm)	63.91±5.22	64.36±4.88	65.09±5.96	0.874
Oxygen saturation (%)	97.36±1.43	97.18±1.54	97.09±1.58	0.912

Description: PJJ: Plyometric – jumping jacks; PCJ: Plyometric – countermovement jump; PTJ: Plyometric – tuck jump. Presentation of data with mean±SD. p-value obtained by analysis of One-way ANOVA.

Table 2. Results of pre, post, delta (Δ) analysis of speed, strength, and limb muscle power in the three groups

Parameter	PJJ (n = 11)	PCJ (n = 11)	PTJ (n = 11)	p-value
Pre-Speed (second)	4.56±0.16	4.61±0.15	4.55±0.19	0.636
Post-Speed (second)	4.36±0.15*†	4.54±0.14	4.48±0.18	0.038
Δ-Speed (second)	-0.20±0.12*†	-0.07±0.04	-0.06±0.02	0.000
Pre-Limb muscle strength (kg)	111.45±18.94	117.73±21.03	115.46±17.66	0.744
Post-Limb muscle strength (kg)	139.27±20.23	129.55±19.24	125.91±18.62	0.263
Δ-Limb muscle strength (kg)	27.82±7.63*†	11.82±6.34	10.46±5.59	0.000
Pre-Limb muscle power (joule)	422.86±34.61	410.70±38.25	404.20±45.63	0.542
Post-Limb muscle power (joule)	493.12±49.24*	462.20±38.55	441.78±46.90	0.039
Δ-Limb muscle power (joule)	70.26±24.83*†	51.50±7.99*	37.58±15.00	0.001

Description: (*) Significantly different from PCJ ($p \leq 0.05$). (†) Significantly different from PTJ ($p \leq 0.05$). p-value was obtained by One-way ANOVA analysis and followed by Least Significant Difference (LSD) post-hoc test. Presentation of data with mean±SD.

et al. (2022) showed that plyometric training for 8 weeks had a positive impact on increasing physical fitness, such as strength, agility, and muscle power, and reducing the risk of muscle damage. Most of the previous studies discussed the effects of plyometric training on adolescent athletes, such as baseball, soccer, and basketball (Kim et al. 2022; Beato et al., 2018; Arede et al., 2019). Marzouki et al. (2022) found that a plyometric training program induces improvements in physical fitness, which may have a transfer to health status during childhood therefore, in this study we will discuss the benefits of plyometric training on increasing speed, strength, and leg muscle power and the benefits that will be obtained in improving the quality of daily life in adolescents who are in school. Regular physical exercise has a very positive impact on the body (Pranoto et al., 2020), while a lack of physical activity can cause a decrease in muscle mass (Distefano & Goodpaster, 2018). Low muscle mass is associated with a risk of cognitive impairment and dementia (Oudbier et al. 2022).

Plyometric training has been shown to improve strength, speed, and agility performance (Hariyanto et al., 2022). Plyometric training use a stretch-shortening cycle that involves eccentric stretching to the muscle and is directly followed by concentric contraction (Munshi et al., 2022). Examples of plyometric training, such as explosive jumps, hops, bounds, and skips (Morris et al., 2022). Plyometric training shows that strength training under unstable conditions results in a significant performance increase in a measure of muscle strength, possibly due to higher muscle activation when exercising on an unstable surface (Negra et al., 2017; Behm & Colado, 2013). There are as many strength and conditioning programs as there are individual doctors who develop programs. Rehabilitation programs have changed dramatically over the last few years. Regardless of program objectives, whether they are used in the final phase of rehabilitation, for strength and conditioning, or performance enhancement, plyometric training should play an integral part in the program (Davies et al., 2015; Chmielewski et al., 2006).

Plyometrics is a very popular form of physical conditioning of healthy individuals which has been studied extensively over the last few decades (Slimani et al., 2016). Marzouki et al. (2022) explained that the application of a four-week plyometric program during physical education sessions instead of some physical education training led to higher jumps, linear running speed, agility, balance, and endurance than non-plyometric training among untrained schoolchildren. In particular, short-distance sprinting ability, agility, and vertical jump are discriminatory in terms of elite and sub-elite youth soccer players (Aloui et al., 2022; Reilly et al., 2000). In many courts and field sports such as basketball, rugby, and football, elite versus sub-elite athletes are characterized by better muscle strength and power, balance, linear sprints, and reactive change of direction (COD) appearance (Makhlouf et al., 2018; Asadi et al., 2017). Regular physical activity and training can improve an individual's quality of life (for example, having more energy reserves in muscles, better mood, feeling more relaxed, sleeping more soundly, improving cognitive function, and improving body metabolism) (Park & Park, 2022). Therefore, plyometric training as a form of physical training has many health benefits and regular plyometric training in this study has been shown to significantly increase limb muscle power, limb muscle strength, and speed.

Conclusion

In general, our findings show that plyometric jumping jacks, countermovement jumps, and tuck jumps performed for 30 minutes/session, with an intensity of 70-90% 1-RM, frequency 3x/week for 6 weeks is effective in increasing limb muscle power, strength and speed. limb muscles, and speed. However, jumping jacks plyometric training is more optimal in increasing limb muscle power, limb muscle strength, and speed compared to countermovement jump and tuck jump plyometric training.

Conflict of interest

The authors do not have any conflicts of interest.

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ПОЗИТИВНИЙ ВПЛИВ ПЛІОМЕТРИЧНИХ ТРЕНУВАНЬ НА ЗБІЛЬШЕННЯ ШВИДКОСТІ, СИЛИ ТА ПОТУЖНОСТІ М'ЯЗІВ КІНЦІВОК У МОЛОДИХ ЧОЛОВІКІВ

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Реферат. Стаття: 7 с., 2 табл., 1 рис., 66 джерел.

Метою дослідження було довести ефективність пліометричного тренування з виконанням стрибка на місці ноги разом, ноги нарізно, стрибка у висоту з присіду та стрибка у висоту з підтягуванням колін до грудей у збільшенні швидкості, сили та потужності м'язів кінцівок у молодих чоловіків.

Матеріали та методи. У дослідженні добровільно взяли участь загалом 33 чоловіки віком 18-22 років зі студентів церковної школи Сантрі Пондок Песантен, Ан-Нур 2 Аль-Муртадло, регентство Маланг (Індонезія). Учасників розділили на 3 експериментальні групи: PJJ (n = 11, пліометрика – стрибки на місці ноги разом, ноги нарізно), PCJ (n = 11, пліометрика – стрибок у висоту з присіду) та PTJ (n = 11, пліометрика – стрибок у висоту з підтягуванням колін до грудей). Тренування з виконанням стрибків на місці ноги разом, ноги нарізно, стрибка у висоту з присіду та стрибка у висоту з підтягуванням колін до грудей проводили по 30 хвилин/заняття, з інтенсивністю 70-90%, 1 повтор максимум, із частотою 3 рази/тиждень протягом 6 тижнів. Для вимірювання потужності м'язів кінцівок використовували цифровий вимірювач висоти стрибка, для вимірювання сили м'язів кінцівок використовували динамометр для спини та ніг, а для вимірювання швидкості використовували біг на 30 метрів. У методиці аналізу даних використовували t-критерій Стьюдента для парних вибірок із рівнем значущості 5%.

Результати. Одержані результати були такими: порівняння середньої швидкості між результатами попереднього та підсумкового тестування для PJJ (4,56±0,16 проти 4,36±0,15 секунди, ($p \leq 0,001$)), PCJ (4,61±0,15 проти 4,54±0,14 секунди, ($p \leq 0,001$)), PTJ (4,55±0,19 проти 4,48±0,18 секунди, ($p \leq 0,001$)), сили м'язів кінцівок між результатами попереднього та підсумкового тестування в PJJ (111,45±18,94 проти 139,27±20,23 кг, ($p \leq 0,001$)), PCJ (117,73±21,03 проти 129,55±19,24 кг, ($p \leq 0,001$)), PTJ (115,46±17,66 проти 125,91±18,62 кг, ($p \leq 0,001$)), потужності м'язів кінцівок між результатами попереднього та підсумкового тестування в PJJ (422,86±34,61 проти 493,12±49,24 джоуля, ($p \leq 0,001$)), PCJ (410,70±38,25 проти 462,20±38,55 джоуля, ($p \leq 0,001$)), PTJ (404,20±45,63 проти 441,78±46,90 джоуля, ($p \leq 0,001$)).

Висновки. На підставі результатів дослідження було зроблено висновок, що пліометричні стрибки на місці ноги разом, ноги нарізно, стрибки у висоту з присіду та стрибки у висоту з підтягуванням колін до грудей, які виконували по 30 хвилин/заняття з інтенсивністю 70-90%, 1 повтор максимум, із частотою 3 рази/тиждень протягом 6 тижнів, є ефективними для збільшення потужності м'язів кінцівок, сили та швидкості.

Ключові слова: пліометричні тренування, швидкість, сила м'язів кінцівок, потужність м'язів кінцівок.

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Cite this article as: Putera, S.H.P., Setijono, H., Wiriawan, O., Nurhasan, Muhammad, H.N., Hariyanto, A., Sholikhah, A.M., Pranoto, A. (2023).Positive Effects of Plyometric Training on Increasing Speed, Strength and Limb Muscles Power in Adolescent Males. *Physical Education Theory and Methodology, 23*(1), 42-48. https://doi.org/10.17309/tmfv.2023.1.06

Received: 04.09.2022. Accepted: 03.01.2023. Published: 28.02.2023