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# A SIX-WEEK PLYOMETRIC TRAINING PROGRAM IMPROVES EXPLOSIVE POWER AND AGILITY IN PROFESSIONAL ATHLETES OF EAST JAVA

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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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**Abstract**

**The study purpose** was to prove the effectiveness of a plyometric training program in increasing explosive power and agility in professional athletes of East Java.

**Materials and methods.** This study is a pre-experiment with a research design of One Group Pretest-Posttest. A total of 15 male athletes from athletics and swimming at the Pusat Pendidikan dan Pelatihan Olahraga Pelajar (PPLP) East Java, Indonesia, aged 15-17 years, body mass index (BMI) 18.5-24.0 kg/m$^2$, normal blood pressure, normal resting heart rate, voluntarily participated in the study. The plyometric training program (hurdle-box jumps) was carried out for 30 minutes/training session with an intensity of 80-90% HRmax with a frequency of 3x/week for six weeks. Measuring the explosive power of the horizontal leg muscles used the Standing Broad Jump Test, while measurement of the explosive power of the vertical leg muscles used the Digital Jump Meter Test. Measurement of agility used Shuttle Run Test, and explosive power and agility were measured during pre-training and six weeks post-training. Data analysis used the Paired Sample T-Test with a significance level of 5% using the Statistical Package for Social Science (SPSS) version 21 software.

**Results.** The results of the study showed that there was a significant difference in the average increase in explosive power horizontally, vertically, and agility between pre-training vs. post-training ($p \leq 0.001$).

**Conclusions.** In general, it can be concluded that the plyometric training program (hurdle-box jumps) carried out 3x/week for six weeks effectively increases the explosive power of the horizontal leg muscles, the explosive power of the vertical leg muscles, and increases agility.

**Keywords:** plyometric training, hurdle-box jumps, explosive power, agility.

## Introduction

Plyometrics is a popular form of physical conditioning for healthy individuals and has been studied extensively over the past few decades (Slimani et al., 2016). Plyometrics are jumping training that involve the action of the stretch-shortening cycle muscles (Bedoya et al., 2015; Markovic & Mikulic, 2010; Meylan & Malatesta, 2009). Plyometrics are effective for increasing tendon stiffness, improving jumping performance, and strength of the lower body (Ramírez-delaCruz et al., 2022). In addition, plyometrics providing to increases agility (Haj-Sassi et al., 2011; Thomas et al., 2009). Plyometric training are usually bodybuilding training that involve stopping, starting, and explosively changing directions. This movement is a component that can help in developing agility (Miller et 2006; Craig, 2004; Miller et al., 2001; Parsons & Jones, 1998; Yap & Brown, 2000; Young et al., 2001).

During sports and daily physical activities, the most attribute of skeletal muscle is the ability to generate power, the product of strength and speed of movement (Kraemer & Newton, 2000). Sports, such as football, handball, basketball, and rugby which are required the ability to make changes in direction quickly (Change-of-direction) (Nygaard Falch et al., 2019). Results by (Kozinc et al., 2021) stated that the strength of several muscles of the lower leg, in particular the hip abductors and adductors, trunk muscles, hip rotators, extensors, and flexors, as well as knee and ankle flexors and extensors should be considered when aiming to improve change-of-direction performance. This proves that explosive

power and agility are important, especially in supporting athlete performance.

Optimal plyometric program design requires control over training level, type of training surface, type of training, program duration, volume (sets, repetitions, weights), intensity, rest intervals between sessions, and repetitions between sets (Asadi & Ramírez-Campillo, 2016; Arazi, 2012; Sáez-Sáez de Villarreal et al., 2010). This is intended to achieve the target of the training and reduce the risk of injury. Plyometric training has proven to be a safe training option when programmed properly, especially when given in a supervised setting (Vetrovsky et al., 2019).

Plyometric training have been shown to be beneficial in sports and activities of daily living, but there is little scientific information available to determine whether plyometric training are really effective at increasing explosive power and agility. Therefore, this study aims to prove the effect of a plyometric training program on explosive power and agility in East Java professional athletes. We hypothesize that a six-week plyometric training program can improve explosive power and agility in East Java professional athletes.

## Materials and Methods

### *Study participants*

This research is a pre-experimental research design with One Groups Pretest-Posttest Design. A total of 15 male athletes from athletics and swimming at the Student Sports Education and Training Center (PPLP) East Java, Indonesia with inclusion criteria aged 15-17 years, body mass index (BMI) 18.5-24.0 kg/m$^2$, normal blood pressure, normal resting heart rate and voluntarily participated in the study. All subjects received information both orally and in writing before conducting the research and respondents also gave a statement that they were willing to participate in the research by signing an informed consent. All procedures performed in our study complied with the Declaration of the World Medical Association of Helsinki on the ethical conduct of research involving human subjects.

### *Study organization*

The plyometric training program (hurdle-box Jump) is implemented and supervised by professional officers from PPLP East Java, Indonesia. Plyometric training (hurdle-box Jump) is performed for 30 minutes/session with an intensity of 80-90% of HRmax with a frequency of 3x/week for six weeks. During plyometric training (hurdle-box Jump) heart rate monitoring using a polar heart rate monitor (Polar H10 Bluetooth Heart Rate Sensor & Fitness Tracker, Polar, Kempele, Finland) (Andarianto et al., 2022).

Data collection for height measurement using Stadiometer (Seca Corporation, CHINO, California, USA) (Rejeki et al., 2021). Body weight was measured using a digital scale (OMRON HN-289, Osaka, JAPAN) (Sugiharto et al., 2022). BMI is calculated by dividing weight (kg) by height (m$^2$) (Raharjo et al., 2021). Measuring blood pressure using a digital sphygmomanometer (OMRON Model Deluxe HEM-8712 BASIC, JAPAN) on the non-dominant arm three times in a row with a 2-minute rest interval between the two measurements, then the average value of the three measurements is taken (Andarianto et al., 2022; Raharjo et al., 2021). Measurement of horizontal leg muscle explosive power using the Standing Broad Jump (SBJ) Test (Tai et al., 2021), while measuring the explosive power of vertical leg muscles using the Jump Meter Digital (MD) Test. Agility measurement using the Shuttle Run Test (Kutlu et al., 2012). Explosive power and agility measurements were carried out pre-training and six weeks post-training.

### *Statistical analysis*

The statistical analysis technique uses the Statistical Package for Social Science (SPSS) version 21 software. The normality test uses the Shapiro-Wilk test, while to compare the difference in mean explosive power and agility between pre-training and post-training, Paired Sample T-Test is used. All statistical analyzes use the significant level ($p \leq 0.05$). All data displayed Mean ± Standard Deviation (SD).

## Results

The results of descriptive analysis of the average characteristic data of research subjects including age, height, weight, body mass index, leg length, resting heart rate, systolic blood pressure, and diastolic blood pressure are presented in Table 1.

**Table 1.** The results of the descriptive analysis of the characteristics of the research subject

| Parameters | n | Mean | Std. Deviation |
|---|---|---|---|
| Age (yrs) | 15 | 15.80 | 0.86 |
| BW (kg) | 15 | 70.67 | 8.38 |
| BH (m2) | 15 | 1.77 | 0.05 |
| BMI (kg/m$^2$) | 15 | 22.62 | 3.29 |
| Leg Length (cm) | 15 | 98.53 | 1.77 |
| RHR (bpm) | 15 | 68.87 | 3.04 |
| SBP (mmHg) | 15 | 115.87 | 3.83 |
| DBP (mmHg) | 15 | 75.93 | 4.04 |

Description: BW: Body weight; BH: Body height; BMI: Body mass index; RHR: Resting heart rate; SBP: Systolic blood pressure; DBP: Diastolic blood pressure

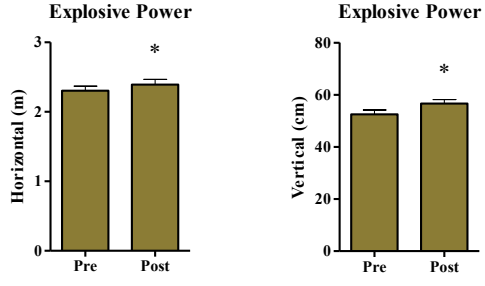


**Fig. 1.** The results of the analysis of the explosive power of the horizontal and vertical leg muscles between pre-training vs. post-training Note: (*) Significant vs. pre-training ($p \leq 0.001$). p- were obtained by using the Paired Samples T-Test. All data are displayed with Mean±SD

Based on Figure 1, the results of the Paired Samples T-Test show that there is a significant difference in the average increase in horizontal explosive power between pre-training vs. post-training (2.31±0.07 vs. 2.39±0.07 meters (p-values=0.000)). Likewise, the average increase in vertical explosive power before training vs. after training also shows a significant difference (52.47±1.73 vs. 56.67±1.50 centimeter (p-values=0.000)). The results of agility analysis between pre-training vs. post-training are presented in Figure 2.

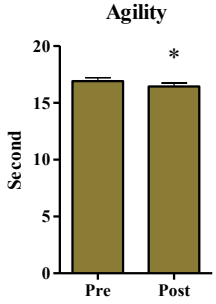


**Fig. 2.** Results of agility analysis between pre-training vs post-training Note: (*) Significant vs. before practice ($p \leq 0.001$). p- values obtained by the Paired Samples T-Test. All data are displayed with Mean±SD

Based on Figure 2, the results of the Paired Samples T-Test show that there is a significant difference in the average increase in agility between pre-training vs. post-training (16.89±0.31 vs. 16.43±0.30 second (p-values=0.000)).

## Discussion

This study aims to determine the effect of six weeks of a plyometric training program on improving explosive power and agility in professional athletes in east java. Our findings show that giving a plyometric training program (hurdle-box Jump) which is done 3x/week for six weeks is effective in increasing explosive power and agility. The results in this study are in line with the results of Kim et al. (2022), that plyometric training carried out for eight weeks has a positive effect on increasing physical fitness, such as maximum strength, agility, and power. Strengthened by (Yáñez-García et al., 2022), that plyometric training can significantly increase explosive power in athletes. Plyometric training are usually bodybuilding training that involve stopping, starting, and explosively changing directions. This training can help in developing agility (Parsons & Jones, 1998; Yap & Brown, 2000; Young et al., 2001).

Plyometric training has proven to be an effective method for improving several physical qualities such as strength and jumping height, running, agility, sprint speed, and endurance (Oxfeldt et al., 2019; Lum et al., 2019; de Villarreal et al., 2008; van de Hoef et al., 2020). In addition, plyometric training can also increase endurance. Results by (Lum et al., 2022) compared the effect of isometric strength training with plyometric training on endurance running performance, showing that both types of training are effective in increasing muscle endurance during running. Plyometric training seem to be an effective and safe training mode for increasing leg muscle volume, thigh muscle volume, thigh and calf circumference, and muscle pennation angle. Therefore, plyometric training are effective for increasing muscle size and architecture, with potential implications in several clinical and training-related contexts (Ramirez-Campillo et al., 2022).

Plyometric training is one of the jumping-type training methods known as the stretch-shortening cycle which is based on neurophysiological mechanisms (Kim et al., 2022; Bedoya et al., 2015). The stretch-shortening cycle increases the ability of the nervous system and muscles to produce maximum strength in a short period, encouraging the use of plyometric training as a bridge between strength and speed (Markovic & Mikulic, 2010). The goal of plyometric training is to increase the strength of subsequent movements by using the natural elastic components of muscles and tendons and the stretch reflex (Bedoya et al., 2015; Meylan & Malatesta, 2009). Plyometric training use the stretch-shortening cycle method by using muscle lengthening (eccentric) movements that are rapidly followed by muscle shortening (concentric) movements (Davies et al., 2015; Chu, 1998; Ebben et al., 2008). de Villarreal (2009) found that a combination of plyometrics using body weight, including countermovement jumps, depth jumps, and squat jumps, resulted in a 4.7% to 15% increase in vertical jump height. The effectiveness of plyometric training may also depend on the training design and the length of the intervention period (Silva et al., 2019; Çankaya et al., 2018). Plyometric training has proven to be a safe training option when programmed properly, especially when given in a supervised setting (Vetrovsky et al., 2019). It can therefore be concluded that both plyometric and resistance training interventions can produce similar effects on overall muscle hypertrophy, at least for the lower extremity muscle groups, in untrained and recreationally trained individuals, and during the short-term intervention period (Grgic et al. al., 2021). In addition, plyometric training can also be an effective training technique to improve an athlete's agility (Cherni et al., 2019).

## Conclusion

In general, it can be concluded that giving a plyometric training program (hurdle-box Jump) which is carried out 3x/week for six weeks is effective in increasing the explosive power of horizontal leg muscles, the explosive power of vertical leg muscles, and increasing agility in Athletics and Swimming Athletes At the Pusat Pembinaan dan Latihan Pelajar (PPLP) East Java.

## Conflict of interests

The authors state that there is no conflict of interests.

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# ШЕСТИТИЖНЕВА ПРОГРАМА ПЛІОМЕТРИЧНИХ ТРЕНУВАНЬ ПОКРАЩУЄ ВИБУХОВУ СИЛУ ТА СПРИТНІСТЬ У ПРОФЕСІЙНИХ СПОРТСМЕНІВ СХІДНОЇ ЯВИ

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

Реферат. Стаття: 8 с., 1 табл., 2 рис., 42 джерела.

**Мета дослідження** полягала в тому, щоб довести ефективність програми пліометричних тренувань у підвищенні вибухової сили та спритності у професійних спортсменів Східної Яви.

**Матеріали та методи.** Це дослідження є попереднім експериментом з планом попереднього та підсумкового тестування на одній групі. У дослідженні добровільно взяли участь загалом 15 спортсменів чоловічої статі з легкої атлетики та плавання в Навчально-тренувальному центрі студентського спорту (PPLP), Східна Ява, Індонезія, віком 15-17 років,

індекс маси тіла (ІМТ) 18,5-24,0 кг/м$^2$, нормальний артеріальний тиск, нормальна ЧСС у стані спокою. Програму пліометричних тренувань (стрибки з перешкодами) проводили по 30 хвилин на тренування з інтенсивністю 80-90% максимальної ЧСС (HRmax) з частотою 3 рази на тиждень протягом шести тижнів. Для вимірювання вибухової сили горизонтальних м'язів ніг використовували тест «Стрибок у довжину з місця», тоді як для вимірювання вибухової сили вертикальних м'язів ніг використовували тест «Цифровий вимірювач висоти вертикального стрибка». Для вимірювання спритності використовували тест «Човниковий біг», а вибухову силу та спритність вимірювали в період до початку тренувань та через шість тижнів після тренувань. Для аналізу даних використовували t-критерій Стьюдента для парних вибірок за рівня значущості 5% із застосуванням програмного забезпечення Statistical Package for Social Science (SPSS) версії 21.

**Результати.** Результати дослідження показали, що існує статистично значуща різниця в середньому збільшенні вибухової сили по горизонталі, вертикалі та спритності між періодами до та після тренувань ($p \leq 0,001$).

**Висновки.** Загалом можна дійти висновку, що програма пліометричних тренувань (стрибки з перешкодами), яку проводять 3 рази на тиждень протягом шести тижнів, ефективно збільшує вибухову силу горизонтальних м'язів ніг, вибухову силу вертикальних м'язів ніг і підвищує спритність.

**Ключові слова:** пліометричні тренування, стрибки з перешкодами, вибухова сила, спритність.

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