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ENHANCING STRENGTH, LEG MUSCLE EXPLOSIVE POWER, AND MUSCLE HYPERTROPHY USING HURDLE-BOX JUMP PLYOMETRIC

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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 examine and analyze the effect of developing a hurdle-box jump plyometric model on muscle strength, explosive power, and hypertrophy.

Materials and methods. This research was an experimental study with a two group pretest-posttest design. The sample in this study was male sub-elite athletes from various sports aged 15-17 years who were selected at random sampling totaling 22 athletes, divided into 2 (two) groups, the treatment group using plyometric hurdle-box jump development (n = 11) and the control group using plyometric barrier hops (n = 11).

Results. The results showed that: (1) there was a significant effect of plyometric hurdle-box jump exercise on strength, leg muscle explosive power, and muscle hypertrophy, (2) there was a significant effect of plyometric barrier hops exercise (control group) on strength, leg muscles explosive power, and muscle hypertrophy, and (3) there was a significant difference between plyometric hurdle-box jump exercises and plyometric barrier hops exercises (control group) on strength, leg muscle explosive power, and muscle hypertrophy.

Conclusions. The percentage increase in pretest and posttest scores on strength, leg muscle explosive power, and muscle hypertrophy showed that the hurdle-box jump plyometric exercise group was better than the control group (barrier hops).

Keywords: plyometric exercise, strength, leg muscle explosive power, muscle hypertrophy, lower extremity.

Introduction

To achieve maximum performance in achievement sports, very long coaching is needed (Bompa & Buzzichelli, 2019). Trainers, sportsmen, nutritionists, and several other experts such as experts in physical conditions and physiology also play an important role in this achievement (Barnamehei et al., 2020). Coaching starts from the multilateral stage with the introduction of various sports to the specialization stage of one particular branch that is really involved and prospective for maximum achievement (Clemente et al., 2016). The role of the trainer is very large in the process, including preparing the motor skills (physical), technique, tactics, and mentality of athletes (Clark et al., 2018).

Physical elements, especially leg power, are needed in achievement sports to support and support performance when practicing or competing (Asadi, 2016). Efforts to prepare these abilities have been prepared by trainers with various forms of exercise applied (DeWeese et al., 2015). The methods used vary widely, both using inner loading and outer loading (Nygaard Falch et al., 2019). However, until now the effective form of exercise to increase leg muscle power is still being debated (Bompa & Buzzichelli, 2019). Therefore, research on the effect of developing plyometric hurdle-box jump models on increasing strength, leg muscle explosive power, and muscle hypertrophy is necessary.

Plyometric exercises that use inner load have been used as an exercise method, especially to develop strength, speed, and explosive power (Asadi & Ramírez-Campillo, 2016). Strength, speed and power are a series of very important physical components in various sports (Blocquiaux et al., 2020). In the sport of cycling, leg muscle power has a greater contribution, when compared to the elements of balance and agility (33% leg power, 13% balance, and 26% agility) (Douglas et al., 2021). This shows that leg muscle power is also very necessary in sports, especially sports that require fast movements such as athletics, swimming, tennis (Castillo et al., 2012). Muscle explosive power in both the upper and lower extremities is a dominant physical component and has a major role in improving athlete performance (Branco et al., 2021). Plyometric training principles can be used in various other sports with training loads that are tailored to each sport (Cezar et al., 2013). With plyometric exercises a person can increase strength, muscle explosive power, and hypertrophy through the process of stretching and shortening of muscle fibers (Chaabene et al., 2020).

From the various descriptions above, the form of plyometric training needs to be developed so that it can be used effectively and efficiently in various sports (Donald A. Chu & Gregory D. Myer, 2013). The development of the exercise used in this research is the plyometric hurdle-box jump model, which is jumping forward with a given obstacle or stimulus in the form of a goal and a box, each height of which has been adjusted and adjusted to the anthropometric condition of the athlete (sample) (Aminaei et al., 2017). The basis for giving weights to the plyometric hurdle-box jump exercise refers to studies of the principles and periodization of the exercise (Cuthbert et al., 2021).

The study purpose was to examine and analyze the effect of developing a hurdle-box jump plyometric model on muscle strength, explosive power, and hypertrophy.

Materials and Methods

Study participants

The design in this study used a two-group pretest-posttest design. This method is to tests the effect of one or more variables on other variables. The samples used in this study were athletes from several sports aged 15-17 years with a total sample of 22 athletes who were divided into two treatment and control groups. Samples from PUSLATKOT KONI Kediri City which was prepared for PORPROV East Java VII 2022. The sample was selected from several sports athletes who have at least > 3 (three) years of training, have won/ranked 3 (three) major competitions at the East Java Province level, and have no history of recurrent severe injuries to the lower extremities of the body. The sample was divided into two (2) groups, the treatment group using the development of plyometric hurdle-box jump (n = 11) and control groups using plyometric barrier hops (n = 11) samples and parents have read and filled Informed consent for approval to be sampled research and provide an understanding of the effects of the given exercise.

Study organization

Determination of treatment and control groups was selected based on a simple random sampling technique. The treatment group was given a hurdle-box jump plyometric development exercise with a frequency of 3 times/week for 4 weeks with the number of obstacles (hurdles and boxes) increasing every week. The control group was given plyometric barrier hops treatment with the same loading. This research has received an ethics test certificate from the Unusa Ethics Committee. All tests (instruments) selected were to determine the effect of exercise, performed before and after 4 weeks of exercise intervention. Tests are assessed and administered in one session (morning 07:00-09.00 or afternoon 15.30-17.30). The first test scores are leg muscle strength using a leg dynamometer, then leg muscle explosive power using jump MD, and the last item is measuring muscle hypertrophy using a candy mini meter. Each test item is carried out 2 (two) times to reduce the occurrence of human errors. In the implementation of the test, a 1-2 minute rest period is given in 1 (one) test item and 3-5 minutes between test items to obtain maximum athlete condition so that the test results can be taken optimally. All samples/athletes are encouraged and asked not to do strenuous activities within 1x24 hours before the test is carried out both on the initial ability test (pretest) and the final ability test (posttest), in addition, samples/athletes are advised not to consume heavy food < 2 hours before carrying out the test. This test is conducted on a gravel track, and the test takers wear training/sports equipment. Before the test, participants warmed up both dynamically and statically for ± 30 minutes to avoid injury to the organs involved.

Statistical analysis

To test the normality of the data used Kolmogorov Smirnov. The test criteria, if the statistical significance of the calculated price is greater than = 0.05 (5%), the data distribution is normal. To calculate the data homogeneity test, the Levene Test formula is used. The test criteria, if the statistical significance of the calculated price is greater than = 0.05 (5%), the variance of the data is homogeneous. The data analysis technique used is the F-test using the SPSS program.

Results

Descriptive Statistics

The statistical descriptive of the plyometric hurdle-box jump exercise development group is presented in Table 1.

Table 1. Descriptive Statistics of the Hurdle-Box Jump Group

Statistics	Strength		Explosion power		Hypertrophy	
	Pre	Post	Pre	Post	Pre	Post
N	11	11	11	11	11	11
mean	220.0	278.56	52.50	57.25	48.21	50.66
elementary school	46.22	27.732	6.240	5.754	3.324	3.591
Min	156.0	217.00	45.00	51.00	45.30	47.61
Max	291.0	301.00	68.00	70.00	56.75	61.25
Sum	3536.0	4473.0	856.0	932.0	787.3	826.55

Based on table 1, there is an increase in the average level of strength, explosive power, and muscle hypertrophy. Average strength from 220 kg to 278.56 kg. The average leg muscle explosive power from 52.50 cm to 57.25 cm. The mean muscle hypertrophy from 48.21 cm to 50.66 cm.

Table 2. Descriptive Statistics of the Control Group (Barrier Hops)

Statistics	Strength		Explosion power		Hypertrophy	
	Pre	Post	Pre	Post	Pre	Post
N	11	11	11	11	11	11
mean	224.25	253.37	52.25	54.68	49.79	50.59
elementary school	48.452	38.964	4.534	4.551	3.695	3.582
Min	156.0	179.00	41.00	42.00	41.30	41.85
Max	296.0	301.00	62.00	64.00	54.12	54.92
Sum	3614.0	4080,0	853.0	892.0	795.35	807.95

Based on table 2, there is an increase in the average level of strength, explosive power, and muscle hypertrophy. Average strength from 224.25 kg to 253.37 kg. The average leg muscle explosive power from 52.25 cm to 54.68 cm. The mean muscle hypertrophy from 49.79 cm to 50.59 cm. After descriptive analysis, normality and homogeneity tests were carried out using the Kolmogorov Smirnov test and Levene test.

Normality Test Results

Table 3. Normality Test

Group	p	Sig.	Information
Hurdle-Box Jump Group			
Strength Pretest	0.635	0.05	Normal
Strength Posttest	0.362	0.05	Normal
Explosive Power Pretest	0.833	0.05	Normal
Explosive Power Posttest	0.942	0.05	Normal
Pretest Hypertrophy	0.681	0.05	Normal
Posttest Hypertrophy	0.883	0.05	Normal
Control Group (Barrier Hops)			
Strength Pretest	0.562	0.05	Normal
Strength Posttest	0.744	0.05	Normal
Explosive Power Pretest	0.906	0.05	Normal
Explosive Power Posttest	0.761	0.05	Normal
Pretest Hypertrophy	0.765	0.05	Normal
Posttest Hypertrophy	0.852	0.05	Normal

Based on table 3, it can be seen that all data have a p value (Sig.) > 0.05, meaning that the variables are normally distributed.

Homogeneity Test Results

The results of the homogeneity test of this study can be seen in Table 4.

Table 4. Homogeneity Test

Group	df1	df2	sig,	Information
Group Hurlde-Box Jump				
Pre-post Strength	1	11	0.112	Homogeneous
Pre-post Explosive Power	1	11	0.756	Homogeneous
Pre-post Hypertrophy	1	11	0.756	Homogeneous
Control Group (Barrier Hops)				
Pre-post Strength	1	11	0.137	Homogeneous
Pre-post Explosive Power	1	11	0.846	Homogeneous
Pre-post Hypertrophy	1	11	0.879	Homogeneous

From Table 4, it can be seen that the pretest-posttest values of sig. p > 0.05, it means that the data is homogeneous.

Based on the results of the F-test in Table 5 above, it can be seen that the calculated F and the F table (df 15) are 4.543 with a p significance value of 0.000. Because F count > F table 4.543, and a significance value of 0.000 < 0.05, this result shows that there is a significant difference. Thus, the hypothesis which states that there is a significant effect of plyometric hurdle-box jump exercise on strength, leg muscle explosive power, and hypertrophy, has been proven.

Table 5. Test-F Results pretest and posttest Group Exercise Plyometic-Box Jump Hurdle

Variable	mean	F_{ht}	F_{tb}	sig,	Difference	%
Strength	220.00 278.56	18.880	4.543	0.000	58.5625	26.49
Explosive power	52.50 57.25	5.009	4.543	0.033	4.75	8.89
Hypertrophy	48.21 50.66	6.510	4.543	0.028	2.45	4.97

Based on the results of the t-test in Table 6, it can be seen that the calculated F and the F table (df 15) are 4.543 with a p significance value of 0.000. Because F count > Ftable 4.543, and a significance value of 0.000 < 0.05, these results indicate that there is a significant difference. Thus the hypothesis which states that there is a significant effect of plyometric barrier hops training on strength, leg muscle explosive power, and hypertrophy, has been proven.

Table 6. Test-F Results pretest and posttest control group (Barrier Hops)

Variable	mean	F_{ht}	F_{tb}	sig,	Difference	%
Strength	224.25 253.37	14.600	4.543	0.042	29.125	12.93
Explosion power	52.25 54.68	5.64	4.543	0.000	2.4327	4.57
Hypertrophy	49.79 50.59	4.754	4.543	0.000	0.79	1.58

Based on the results of the analysis, the data obtained in Table 7. Based on the results of the F-test in Table 7, it can be seen that the calculated F and the F table (df 15) are 4.543

Table 7. F-Test Results of Hurdle-Box Jump Group and Barrier Hops Group (Control)

Variable	mean	F_{ht}	F_{tb}	sig,	Difference	%
Strength	58.5625 29.1250	4.730	4.543	0.038	29.437	26.49 12.93
Explosion power	4.7500 2.4375	6.202	4.543	0.019	2.312	8.89 4.57
Hypertrophy	2.45 0.79	78.659	4.543	0.00	1.66	4.97

with a p significance value of 0.000. Because $F_{count} > F_{table}$ 4.543, and a significance value of 0.000 < 0.05, these results indicate that there is a significant difference between plyometric hurdle-box jump exercises and plyometric barrier hops (control) exercises on strength, leg muscle explosive power, and hypertrophy. These results showed that the average data on strength, leg muscle explosive power, and hypertrophy of the hurdle-box jump plyometric exercise group were better than the plyometric barrier hops exercise group (control).

Discussion

Based on the results of the research that has been carried out, it shows that there is a difference between the mean pretest and posttest, so it can be said that the leg muscle strength of the test-takers has increased significantly, as indicated by the difference in the mean from 221.00 to 279.56. The increase in the results in this study can be seen if the difference between the pretest and posttest means is calculated, namely 58.5625. So it can be concluded that the plyometric hurdle-box jump exercise can increase leg muscle strength by 26.49%. The explosive power of the leg muscles of the test participants experienced a significant increase as indicated by the average difference from 53.5000 to 58.2500. The increase in the results in this study can be seen if the difference between the pretest and posttest means is calculated, which is 4.75. So it can be concluded that the plyometric hurdle-box jump exercise can increase the explosive power of the leg muscles by 8.89%.

Strength is the ability of a muscle or a group of muscles to contract either isotonic, isometric, eccentric and isokinetic with the aim of generating tension against resistance in one work (Egan-Shuttler et al., 2017). Along with physiological adaptation, plyometric training also causes adaptation to several physical elements (Bayindir & Kolayiş, 2015). Plyometric exercises in addition to building strength can also improve the ability of elements of other physical conditions (Angulo et al., 2020). The increase in muscle workability due to weight training is caused by physiological changes that occur in the neuromuscular system (neuromuscular adaptation system) (Farias-Junior et al., 2019).

An increase in muscle size causes stronger muscle contractions (increased explosive power), faster repetition of contractions (increased speed), longer-lasting exercise periods (increases muscle endurance) (Fink et al., 2016). Plyometric exercises are prescribed for both athletes and non-athletes to develop lower body strength (Feriche et al., 2017). Plyometric exercises in addition to increasing strength, there is another goal, namely increasing the size of muscle fibers called hypertrophy (Bostani & Shariati, 2012). Periodization of training determines the target and the number of types of exercise. These results are in line with research conducted by (Clark et al., 2018) that plyometric exercises using pre-arranged or designed loading given to 40 men within 6 weeks with 2 sessions per week showed a significant increase in muscle strength legs.

The muscle hypertrophy of the test participants experienced a significant increase as indicated by the average difference from 49.21 to 51.66. The increase in the results in this study can be seen if the difference between the pretest and posttest means is calculated, which is 2.45. So it can be concluded that plyometric hurdle-box jump exercise can increase muscle fiber size (hypertrophy) by 4.97%.

Muscle hypertrophy is the result of an increase in the number of actin and myosin filaments in each muscle fiber. Strength targets in the preparatory period where training is aimed at increasing large muscle groups such as the legs (Eckardt, 2016). Furthermore, in the preparation period for the second stage of strength training, the goal of strength training is a maximum strength which is continued with power (Fink et al., 2016). Periodization has an effect on increasing muscle strength and hypertrophy (Fischetti et al., 2018). Plyometric exercises can be performed using outer loading such as a vest or weight jacket and a variety of obstacles according to the training objectives and muscle exposure (Gillen et al., 2020). Local muscle damage induced by weight training has also been implicated in mediating muscle growth (Grgic, Schoenfeld, & Mikulic, 2021). Eccentric exercise produces greater gains in lean muscle than concentric and isometric contractions (Vassil & Bazanovk, 2012). This will trigger maximal muscle hypertrophy in response to resistance training is not achieved unless eccentric muscle action is performed (Gordon et al., 2012). Exercise programs that use outer loading will accelerate the process of hypertrophy in muscles (Grgic, Schoenfeld, & Mikulic, 2021). From the results of the analysis, it can be concluded that the plyometric hurdle-box jump exercise is effective for increasing strength, power, and muscle hypertrophy, especially in the lower extremities.

The results showed that there was an effect of plyometric barrier hops training on strength, explosive power, and muscle hypertrophy. It can be seen from each variable that there is a difference between the mean pretest and posttest, so it can be said that the leg muscle strength of the test-takers has increased significantly as indicated by the difference in the mean of 225.25 to 254.38. The increase in the results in this study can be seen if the difference between the pretest and posttest means is calculated, which is 29.125. So it can be concluded that the plyometric barrier hops exercise can increase leg muscle strength by 12.93%. The explosive power of the leg muscles of the test participants experienced a significant increase as indicated by the average difference from 53.2500 to 55.6875. The increase in the results in this study can be seen if the difference between the pretest and posttest means is calculated, which is 2.4327. So it can be concluded that the plyometric barrier hops exercise can increase leg muscle strength by 4.57%. Plyometric barrier hops is one of several plyometric training models by provide obstacles consisting of small hurdles arranged and arranged at a predetermined distance, and easier to implement because the goal used is not too high and suitable to be given to children or children. non-athletes (Fischetti et al., 2018).

The muscle hypertrophy of the test participants experienced a significant increase as indicated by the average difference from 49.77 to 50.56. The increase in the results in this study can be seen when the difference between the pretest and posttest means is calculated, which is 0.79. So it can be concluded that plyometric barrier hops exercise can increase muscle fiber size (hypertrophy) by 1.58%. The training period determines the target and the number of types of exercise (Bompa & Buzzichelli, 2019). Strength targets in the training preparatory period are aimed at increasing large muscle groups such as the legs (Blocquiaux et al., 2020). Furthermore, in the preparation period for the second stage of strength training, the goal of strength training is a maximum strength which is continued with power (Gillen et al., 2020). Furthermore, (Gordon et al., 2012) stated that periodization has an effect on increasing muscle strength and hypertrophy. Pressure on muscle contraction is the most dominant mediator of muscle hypertrophy (Grgic, Schoenfeld, Orazem, et al., 2021). From the results of the analysis, it can be concluded that the plyometric barrier hops exercise is effective for increasing strength, leg muscle explosive power, and muscle hypertrophy.

The results showed that there were differences in the effect of plyometric hurdle-box jump and barrier hops exercises on strength, muscle explosive power, and hypertrophy. Judging from the results of the percentage increase in scores between pretest and posttest, it was shown that the percentage increase in the plyometric hurdle-box jump exercise group was higher than the plyometric barrier hops exercise on strength, explosive power, and hypertrophy. The hurdle-box jump plyometric exercise is better than the barrier hops plyometric exercise on strength, leg muscle explosive power, and hypertrophy.

Exercise plyometric hurdle-box jump is an exercise with jumping movement towards vertical-horizontal with the provision of obstacles wicket as high as 80% of the long legs of athletes and boxes as high as 80% long-calf (gastrocnemius) carried by the rhythm/contraction very rapidly in order to develop and improve strength and leg muscle explosive power in athletes (not recommended for non-athletes). On the other hand, plyometric barrier hops exercise as an exercise by jumping in a vertical direction by providing a small hurdle as high as 30-45 cm which is carried out with a rhythm or rapid contraction with the aim of developing and increasing the strength and explosive power of the user's leg muscles (can be given to athletes). and non-athletes) (Haugen et al., 2019). The plyometric hurdle-box jump and barrier hop exercises have the following characteristics: (a) they both provide an increase in physical biomotor aspects, (b) they allow rapid muscle contraction movements, (c) both require good jumping ability and (d) both allow progressive resistance. These four traits are critical to the benefits an effective plyometric training program offers. Despite the similarities between the hurdle-box jump and the barrier hop, one would assume that the hurdle-box jump is better. Plyometric hurdle-box jump has the following advantages: (a) it is used for exercises that increase most of the body's muscles, (b) it has a high level of safety so it does not injure or injure the wearer, (c) it can be easily moved to suit conditions. the training ground, (d) involve a range of motion and muscle activation similar to that in many sports movements especially for the lower body, and (e) minimize costs (low cost).

Furthermore, this study is supported by (Hayward et al., 2013) that plyometric exercises using the hurdle jump and box jump models are more effective or have a greater effect than plyometric exercises using the barrier hops model. This is also evidenced by (Jakobsen et al., 2013) in his research comparing plyometric hurdle jump and box jump models given to 60 male athletes within 4 weeks with 3 sessions per week showing a significant increase in leg muscle strength. Of the two types of exercise plyometric models of hurdle jumps and box, jumps are superior to the exercise plyometric model of barrier hops.

The effect of plyometric hurdle-box jumps and barrier hops in the study seen from the loading factor showed that there was a significant increase in muscle fiber growth (muscle hypertrophy), in loading the important factor was to provide sufficient load on the muscles that were stimulated to grow (Hammami et al., 2020). The results showed that the plyometric hurdle-box jump exercise effect was more effective than the barrier hops plyometric exercise results. This can be seen from the loading characteristics of the two methods, the plyometric hurdle-box jump exercise involves strong and fast muscle contractions that require a person to use more muscles (Kruse et al., 2015). It can be concluded that the hurdle-box jump plyometric exercise is higher in benefit and effectiveness than the barrier hops plyometric exercise on strength, leg muscle explosive power, and hypertrophy.

Conclusion

Based on the results of the research and the results of data analysis that has been carried out, the following conclusions are obtained: (1) there is an effect of plyometric hurdle-box jump exercise on strength, leg muscle explosive power, and muscle hypertrophy, (2) there is an effect of plyometric barrier hops exercise on strength, leg muscle explosive power, and muscle hypertrophy, (3) there are differences in the effect of plyometric hurdle-box jump exercises and plyometric barrier hops exercises on strength, leg muscle explosive power, and muscle hypertrophy. Based on the percentage increase in pretest and posttest scores on strength, leg muscle explosive power, and muscle hypertrophy, the hurdle-box jump plyometric exercise group was better than the barrier hops plyometric exercise group.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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ПІДВИЩЕННЯ СИЛИ, ВИБУХОВОЇ СИЛИ М'ЯЗІВ НІГ І ГІПЕРТРОФІЇ М'ЯЗІВ ЗА ДОПОМОГОЮ ПЛІОМЕТРИЧНОГО СТРИБКА З БАР'ЄРОМ

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

Реферат. Стаття: 8 с., 7 табл., 36 джерел.

Мета дослідження полягала в тому, щоб вивчити та проаналізувати вплив розробленої пліометричної моделі стрибка з перешкодами на силу м’язів, вибухову силу та гіпертрофію.

Матеріали та методи. Це дослідження було експериментальним дослідженням із двома групами передтест-посттест. Вибіркою в цьому дослідженні були спортсмени-чоловіки з різних видів спорту віком 15-17 років, які були відібрані шляхом випадкової вибірки загальною кількістю 22 спортсменів, поділених на дві групи, група впливу з використанням пліометричного розвитку стрибків з бар’єрами (n = 11) та контрольна група з використанням пліометричних бар’єрних стрибків (n = 11).

Результати. Результати показали, що: (1) був значний вплив пліометричної вправи зі стрибками з бар’єром на силу, вибухову силу м’язів ніг і гіпертрофію м’язів, (2) був значний вплив пліометричних вправ з бар’єрним стрибком (контрольна група) на силу, вибухову силу м’язів ніг і гіпертрофія м'язів, і (3) була значна різниця між пліометричними вправами зі стрибками з бар'єром і пліометричними вправами з бар'єрним стрибком (контрольна група) щодо сили, вибухової сили м'язів ніг і гіпертрофії м'язів.

Висновки. Відсоткове збільшення показників до і після тесту за силою, вибуховою силою м'язів ніг і гіпертрофією м'язів показало, що група пліометричних вправ зі стрибками з бар'єрами була кращою, ніж контрольна група (перескоки з бар'єром).

Ключові слова: пліометричні вправи, сила, вибухова сила м'язів ніг, гіпертрофія м'язів, нижня кінцівка.

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