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## The Effect of Plyometric Exercise towards Agility, Speed, Strength and Explosive Power of Leg Muscle

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### Wpływ ćwiczeń plyometrycznych na zwinność, szybkość, siłę oraz siłę eksplozywną mięśni nóg

#### Streszczenie

Celem niniejszego badania jest sprawdzenie wpływu ćwiczeń z przeskakiwaniem przez przeszkody z drążkiem, szybkim przeskakiwaniem przez przeszkody bokiem oraz bocznych przeskoków przez przeszkody na zwinność, szybkość, siłę i siłę eksplozywną mięśni nóg. Badana grupa składała się z 33 studentów, którzy uczestniczyli w turnieju badmintonu zorganizowanego przez FIO UNESA (Universitas Negeri Surabaya). W badaniach zastosowano metodę badania ilościowego w powiązaniu z metodami *quasi*-eksperymentalnymi. Wyniki pokazały, że grupa I miała wzmocnienie siły kończyn dolnych o 2,89, szybkość o -0,003, zwinność 0,1 i siłę eksplozywną

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mięśni nóg o 1,42. Grupa II miała siłę kończyn dolnych zwiększoną o  $-1,04$ , szybkość o  $0,09$ , zwinność  $-0,19$  i siłę eksplozywną mięśni nóg o  $0,85$ , a grupa III miała siłę mięśni kończyn zwiększoną o  $0,43$ , szybkość o  $1,18$ , zwinność o  $0,36$  i siłę eksplozywną nóg o  $0,71$ . Można zatem wnioskować, że te trzy ćwiczenia wpłynęły na zwinność, siłę i siłę eksplozywną mięśni nóg.

**Słowa kluczowe:** sprawność, mięśnie nóg, trening plyometryczny, siła, szybkość, program treningowy

## Abstract

The aim of this research is to investigate the effect of hurdle box drill with the stick, jump and speed hurdle lateral, and lateral hurdle jump exercises on agility, speed, strength, and explosive power of leg muscles. The sample group of the study consisted of 33 students who participated in badminton FIO UNESA. The methodology used was quantitative research with quasi-experimental methods. The result showed that group I had enhancement on the muscular strength of the limbs for 2.89, speed for  $-0.003$ , agility 0.1 and leg muscle explosive power for 1.42. Group II had the strength of the lower limbs for  $-1.04$ , speed 0.09, agility  $-0.19$  and leg muscle explosive power 0.85 and group III had limbs muscle strength increased for 0.43, speed 1.18, agility 0.36 and leg muscle explosive power 0.71. Therefore, it can be concluded that these three exercises affected the agility, speed, strength and explosive power of leg muscle.

**Keywords:** agility, leg muscle, plyometric training, power, speed, training program

## 1. Introduction

Physics has a role which is used in enhancing athlete performance, especially in sport competition branches. Thus, a good physical condition will be considered to give a positive contribution to the athlete in mastering the sport techniques. The athlete's capacity trained privately becoming the main objective in improving the sport performance. One of the training models used to improve performance is a plyometric exercise. Plyometric exercise is considered to be effective to increase the accomplishment of an athlete's prime condition. It can be used for any kind of sports with the purpose to increase body fitness.

The explanation above is in line with Irandoust and Taheri [5] who stated that the characteristics of plyometric exercises, such as agility, speed, strength and explosive power of leg muscle, showed significant enhancement within the physical fitness performance. Kusnanik, Nasution, and Hartono [7] also claimed that plyometric was the stretching reflects to facilitate the recruitment from muscle unit and eccentric contraction. This was meant to form elastic and contractile energy of muscle component when stretching, followed by concentric contraction. Chu and Myer [2] said that plyometric exercise was the training program to increase the power and strength of an elite athlete. Plyometric exercise is efficient since it is helping to enhance training objective and able to use for a various sport such as football, tennis, or others. Furthermore, plyometric exercise also helps to increase agility that useful for an athlete [10].

Plyometric exercise such as hurdle box drill with a stick, jump and speed hurdle and lateral hurdle jump is using both unilateral and bilateral jump. According to Harrell, the phase-in stepping forward through the hurdle or gate between every leap by pushing the body forward is the phase in which speed and strength are trained [4]. Hurdle hop is defined as a high-speed movement that needs neuromuscular strength and control [11]. However, the plyometric exercise with 6 weeks duration is still contradictive. As what Lehnert, Hulka, Maly, Fohler and Zahalka [8] found that the 6 weeks duration of plyometric exercise did not produce a significant average score of vertical jump test. While Thomas, French and Hayes [16] showed the significant differentiation within 6 weeks of plyometric exercise that could enhance the agility. However, these previous researches did not point to the plyometric exercise that specifies for enhancing the physical condition components. Therefore this study is aimed to know the effect on plyometric exercise against the physical condition component such as agility, speed, strength and explosive power of leg muscle.

Regarding on the objective of this study, two hypotheses will be made in this research. The first hypothesis is the most effective exercise model to increase agility, speed, strength and leg muscle explosive power. The second hypothesis is the differentiation on the hurdle box drill with stick exercise (G1), jump and speed hurdle (G2) and lateral hurdle jump (G3) toward the enhancement of agility, speed, strength, and explosive power of leg muscle.

## **2. Materials and Method**

### **2.1. Subject**

The subject of the research is badminton athletes of Sport Science Faculty, State University of Surabaya 2017 with the total amount are 30 people.

### **2.2. Protocol**

This study used a quantitative using a semi quasi-experiment methodology due to finding the causality between each variable. The variables were divided into free variables, including the plyometric exercise (hurdle box drill with the stick, jump and speed hurdle, lateral hurdle jump) and bound variable which influenced by the free variables with the target on agility, speed, strength, and leg muscle leg explosive power.

Some tests were done to measure the variables, such as back leg and dynamometer to measure the strength, force plate or the Accu power test to measure leg muscle explosive power, the 30 m running test for speed and sidestep test to measure the agility.

### 2.3. Statistics

The statistic in this research is dealing with the mean, standard deviation, variants, maximum and minimum score, normality test, homogeneity test and MANOVA test of leg muscle strength, explosive power, agility and speed of each group. Then the test result will be noted and counted based on the group and exercise model to which it applied. Moreover, the data description is using SPSS 23 (Statistical Program for Social Science) computer program.

### 3. Result

The table 1 below will describe the estimated marginal mean and multiple comparative to answer the hypotheses 1.

**Table 1.** Estimated Marginal Mean and Multiple Comparative LSD

Dependent Variable	(i) Group	(J) Group	Sig.	Mean	
Strength	G1a	G2a	.002	163.8182	
		G3a	.032		
	G2A	G11	.002		137.4545
		G3d	.233		
	G3a	G11	.032		146.7273
		G22	.233		
Speed	G1a	G22	.000	5.0273	
		G31	.609		
	G2s	G1e	.000		5.9727
		G3f	.002		
	G3a	G1s	.609		5.1491
		G22	.002		
Agility	G1w	G2e	.213	35.3636	
		G3e	.148		
	G2d	G1w	.213		33.1818
		G3w	.010		
	G3d	G1s	.148		37.9091
		G2w	.010		
Explosive Power	G1w	G2q	.011	96.3091	
		G3e	.150		
	G2w	G1w	.011		81.6727
		G3e	.229		
	G3w	G1q	.150		88.3182
		G2w	.229		

Source: own research.

Afterwards, Table 2 below will show the answer of hypotheses 2.

**Table 2.** The Effects among the Subjectss

Sources	Dependent Variables	Type III Sumq of Squaress	Dfs	Mean Squares	Fs	Sig.m
Intercept	Strength	735914.667	1	735914.667	2310.674	.000
	Speed	956.242	1	956.242	3127.654	.000
	Agility	41552.758	1	41552.758	2569.72	.000
	Explosive Power	260024.197	1	260024.197	1616.896	.000
Group	Strength	3934.788	2	1967.394	6.177	.006
	Speed	5.819	2	2.910	9.517	.001
	Agility	123.152	2	61.576	3.808	.034
	Explosive Power	1181.546	2	590.773	3.674	.037

Source: own research.

The Table above answers the second hypothesis that there is differentiation on the hurdle box drill with stick exercise (G1), jump and speed hurdle (G2) and lateral hurdle jump (G3) toward the enhancement of agility, speed, strength, and explosive power of leg muscle. Because they are showing some different number of mean on each category. And the highest number comes from strength.

#### 4. Discussion

The result of table 2 above contains a significant value for each group toward the variables – strength, speed, agility and explosive power of leg muscle for sig < 0.05, which meant Ho was rejected or there was significant differentiation in each group toward the variables. It showed that every exercise would be able to influence the bound variables differently. The differentiation occurred since there was a different physiologic mechanism in each exercise. The hurdle box drill with the stick, jump and speed hurdle, and lateral hurdle jump, physiologically, might affect the tense in the leg muscle, respiration, anaerobic capacity, and lactic acid which increase the strength and leg muscle explosive power optimally.

Jump and speed hurdle, according to Harrell, was when the respondent steps forward through the hurdle between every jump, and push himself forward due to produce the speed and strength [4]. Richter et Marshall, Franklin-Miller, King, Falvey, Moran claimed that hurdle hops were a movement with high speed that needs the neuromuscular strength and control [11]. Different from lateral hurdle jump that focused on enhancing agility. With jump movement, cognitive ability and strength can be increased and causes speed. The sudden change in movement direction could happen in a very quick motion that can increase the agility. The effect of plyometric exercise on explosive strength through lower extremity had a positive effect on strength and power [3, 6, 9, 13]. This finding showed that

plyometric exercises has become a valuable tool to be entered in a structural program to increase sports performance.

Based on the MANOVA test using four statistic models, including Pillai's trace, Wilks lambda, Hotelling, Tace, and Roy's largest root, had showed significant results for  $p < 0.05$ . It meant that the hurdle box drill with the stick, jump and speed hurdle, and lateral hurdle jump had a significant effect on the enhancement of agility, speed, strength and explosive power of leg muscle when these came together. Hence,  $H_0$  was rejected, or there was interaction among these exercises toward the improvement of agility, speed, strength and explosive power of leg muscle. Senthil stated that plyometric exercises could increase the strength of abdominal muscle, cardiovascular, pulse reduction and thinking ability [14]. Plyometric exercise started from low intensity to high intensity.

These three exercise models utilized the elastic energy and myopic reflect on strength development. Elastic energy is energy when an object is given a force and then the force is removed; hence the object will be back to its former form. While myopic energy is related to athlete energy derived from the combustion within the body. Myopic energy is obtained from the sports training which done with load or weight that change each day with a purpose that the strength and energy came out more, thus the myopic energy can be formed. Besides, the plyometric exercise can increase the spindle muscle system. Elastic energy used to make the concentration becomes stronger. The combination of the unilateral and bilateral leap was more profitable to induce a significant performance within the plyometric exercise [15].

Plyometric exercise is a stretch-shortening cycle or SSC which started from a long contraction of tendon muscle followed directly with shortening muscle contraction. Kusnaik et Nasution, Hartono said that plyometric exercise had stretching reflect from unit muscle with eccentric contraction due to form the elastic energy when the muscle is stretching, followed with concentric contraction [7]. Plyometric exercise combined the strength and speed to produce power that involves more of fibre muscle to obtain spindle muscle.

Plyometric exercise is one of the exercise models with the purpose to increase athlete's power and speed [2]. Chelly et Ghenem, Abid, Hermassi, Tabka, Shephard stated that plyometric exercise could increase the leg muscle explosive power and speed [1]. Therefore it can be concluded that plyometric exercise, generally, can contribute to enhancing the leg muscle speed and explosive power, especially in badminton which tends to require a high-speed level, agility, and jump ability.

## 5. Conclusion

From the analysis above, it can be concluded that there was significant differentiation on and interaction among plyometric exercise models – hurdle box

with the stick, jump and speed hurdle, and lateral hurdle jump, on the enhancement of agility, speed, strength and explosive power of leg muscle.

## Bibliography

- [1] Chelly M.S., Ghenem M.A., Abid K., Hermassi S., Tabka Z., Shephard R.J. (2010): *Effects of in-season short-term plyometric training program on leg power, jump-and sprint performance of soccer players*. Journal of Strength and Conditioning Research, 24 (10), p. 2670–2676; <https://doi.org/10.1519/JSC.0b013e3181e2728f>.
- [2] Chu D.A., Myer G.D. (2013): *Plyometrics*. United States: Human Kinetics.
- [3] Fatouros I., Jamurtas A., Leontsini D., Taxildaris K., Aggeolusis N., Kostopoulos N., Buckenmeyer P. (2000): *Evaluation of Plyometric Exercise Training, Weight Training, and Their Combination on Vertical Jumping Performance and Leg Strength*. Journal of Strength and Conditioning Research, 11 (4), p. 470–476.
- [4] Harrell R. (2006): *Gymnastics Hurdle*. CrossFit J Artic. (51), p. 1–3.
- [5] Irandoust K., Taheri M. (2014): *Effects of 8 weeks plyometric and strengthening training programme on selected physical fitness factors of elite kabaddi players*. Journal of Fundamental and Applied Life Sciences, 4(4), p. 3942–3948.
- [6] Kotzamanidis C. (2006): *Effect of plyometric training on running performance and vertical jumping in prepubertal boys*. Journal of Strength and Conditioning Research, 20 (2), p. 441–445; <https://doi.org/10.1519/R-16194.1>.
- [7] Kusnanik N., Nasution J., Hartono S. (2011): *Dasar-dasar Fisiologi Olahraga*. Unesa: Unesa University Press.
- [8] Lehnert M., Hulka K., Maly T., Fohler J., Zahalka F. (2013): *The effects of a 6 week plyometric training programme on explosive strength and agility in professional basketball players*. Acta Gymnica, 43(4), p. 7–15; <https://doi.org/10.5507/ag.2013.019>.
- [9] Markovic G. (2007): *Does plyometric training improve vertical jump height? A meta-analytical review*. British Journal of Sports Medicine, 41(6), p. 349–355; <https://doi.org/10.1136/bjism.2007.035113>.
- [10] Mohamed Abd El-Mawgoud Elsayed (2012): *Effect of Plyometric Training on Specific Physical Abilities in Long Jump Athletes*. World Journal of Sport Sciences, 7 (2), p. 105–108; <https://doi.org/10.5829/idosi.wjss.2012.7.2.1174>.
- [11] Richter C., Marshall B., Franklin-Miller A., King E., Falvey E., Moran K. (2014): *Kinematic and kinetic changes in a hurdle hop task following athletic groin pain rehabilitation*. Journal of Science and Medicine in Sport, 18(1), p. e33–e71; <https://doi.org/10.1016/j.jsams.2014.11.217>.

- [12] Roger H. (2006): *Gymnastic Hurdle*. CrossFit Journal Article Reprint, (51), p. 1–3.
- [13] Ronnestad B.R., Kvamme N.H., Sunde A., Raastad T. (2008): *Short-term effects of strength and plyometric training on sprint and jump performance in professional soccer players*. Journal of Strength and Conditioning Research, 22(3), p. 773–780; <https://doi.org/10.1519/JSC.0b013e31816a5e86>.
- [14] Senthil P.D. (2015): *Effects Of Plyometric Training On Physical And Physiological Parameters*. Asian Journal of Science and Technology, 06(12), p. 2113–2116.
- [15] Slimani M., Chamari K., Miarka B., Del Vecchio F.B., Chéour F. (2016): *Effects of Plyometric Training on Physical Fitness in Team Sport Athletes: A Systematic Review*. Journal of Human Kinetics, 53(1), p. 231–274; <https://doi.org/10.1515/hukin-2016-0026>.
- [16] Thomas K., French D., Hayes P.R. (2009): *The effect of two plyometric training techniques on muscular power and agility in youth soccer players*. Journal of Strength and Conditioning Research, 23(1), p. 332–335; <https://doi.org/10.1519/JSC.0b013e318183a01a>.
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