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EFFECT OF PLYOMETRIC DEPTH JUMP AND RIM JUMP EXERCISES ON MUSCLE STRENGTH, FLEXIBILITY, LEG MUSCLE EXPLOSIVENESS AND CREATINE PHOSPINASE IN BASKETBALL PLAYERS

Eko Juli Fitrianto

Department of Sports Science, State University of Jakarta, Indonesia.
*Corresponding Author Email: eko-juli-fitrianto@unj.ac.id

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Abstract

Plyometric depth jump and rim jump exercises are a form of exercise model that predominates anaerobic metabolism which is carried out at high intensity so that it can cause injury to muscle cells. This study aims to analyze the effect of Plyometric Depth Jump and Rim Jump Training on Muscle Strength, Flexibility, Leg Muscle Explosiveness, and Creatine Phospokinase in Basketball Players. This research is a type of experimental research. The population and sample in this study amounted to 28 subjects where the sample will be divided into four groups, and each group will be treated with different variables. The instruments of this study were variable leg muscle strength using a leg dynamometer, leg muscle flexibility using a flexometer using the sit and reach test method and tugkai muscle explosiveness using the Vertical Jump method. The data analysis technique used in this study is by using ANACOVA as well as prerequisite tests and hypothesis tests with a significance level of 0.05 using SPSS Version 26 software. The results of the study showed: 1) There was an influence between the two training methods on the explosive power of the players' leg muscles with a P-Value pretest value of 0.951 and an F test of 0.004. As well as the posttest P-Value value of 0.002 and the F test of 11.66. 2) The effect between the two training methods on the muscle strength of the players' legs with a pretest P-Value of 0.479 and an F test of 0.517. As well as the posttest P-Value value of 0.004 and the F Test of 10.04. 3) The effect between the two training methods on the flexibility of players with a pretest P-Value of 0.192 and an F test of 1.798. As well as the posttest P-Value value of 0.003 and the F test of 10.04. 4) The effect between the two training methods on the Creatine Phospokinase of players with a pretest P-Value value of 0.099 and an F test of 2.935. As well as the posttest P-Value value of 0.005 and the F Test of 9.59. So based on the results of the study, it can be concluded that plyometric depth jump and rim jump exercises have a significant influence on muscle strength, flexibility, leg muscle explosiveness and creatine phospokinase in basketball players.

Keyword: Plyometric Depth Jump, Rim Jump, Muscle Strength, Flexibility, Creatine Phospokinase, Athlete.

INTRODUCTION

The game of basketball is very popular all over the world, which causes the game to constantly change both in terms of rules during the game and the equipment used [1]. This change has an impact on the movement pattern of basketball games that are carried out to the maximum, so that basketball games are classified as anaerobic predominant and are at risk of injury to basketball players [2]. The movement pattern of the basketball game, which is classified as predominant anaerobic, is reflected in the movements that are carried out with high intensity, for example when doing fast break movements, namely making quick attack movements, power lay-ups, which are explosive movements in shooting the ball, jump shots, namely shooting by jumping, offensive and defensive rebounds, namely looting the ball, and power dribble, namely dribbling the ball with explosive movements [1]. Observing movement patterns during training or basketball games, the predominant physical components are leg and arm muscle strength, leg and arm muscle explosiveness and flexibility [3]. According to [4], among the physical components that play the most role in improving basketball players' performance is the explosive power of the leg muscles. In this regard, trainers around the world use the Plyometric depth jump training method and the Plyometric rim jump training method to increase the explosive power of the leg muscles. However, using these two forms of training often causes injuries to basketball players. Explosive movement patterns with strong muscle contractions in a very short period of time can lead to muscle injury [5]. In addition, errors in the landing technique in these two exercises are also very risky to cause injury, because the body weight increases seven times heavier than the previous weight by the time the basketball player's feet land on the floor [6]. Plyometric Depth Jump exercise is a form of Plyometric exercise using additional equipment, namely Plyometric box [7]. This exercise is carried out by starting with a basketball player standing on a Plyometric box, then the basketball player jumps down to the floor with both feet followed by maximum vertical repulsion and is carried out with explosive movements. These jumps are performed continuously according to the volume and intensity of the exercise. According to [8] in his study, there was an increase in muscle explosiveness after doing Plyometric Depth Jump training for six weeks. The same was also stated by [9] that Plyometric Depth Jump training significantly increases the strength and explosiveness of the leg muscles.

The characteristics of movement patterns and high intensity during the Plyometric Depth Jump exercise, this exercise is categorized as anaerobic predominant [10]. Anaerobic activity while doing continuous Plyometric Depth Jump exercises is likely to cause muscle damage. Therefore, it is necessary to seek to prevent heavier muscle damage by looking for muscle damage parameters, including by measuring the level of the enzyme Creatine Kinase or better known as Creatine Phospokinase in the blood. Creatine Phospinase Levels is an enzyme found in the heart organs, skeletal muscles and brain [11]. High-intensity exercise that can cause damage to skeletal muscles can be characterized by increased Creatine Phospinase Levels in the blood [12]. Trainers in addition to using the Plyometric Depth Jump training method can also use the Plyometric Rim Jump training method to increase the explosive power of the leg muscles. The Plyometric Rim Jump training method is a form of Plyometric training method that is often used by basketball coaches [13]. This exercise only requires a basketball hoop or target at a vertical height of 3.05 m from the floor. The Plyometric Rim Jump exercise is done by making maximum vertical jumps to touch the basketball hoop with explosive movements. This jump is performed repeatedly continuously without breaks according to the volume and intensity of the exercise. Repetitive explosive movements during Plyometric Rim Jump exercises are at high risk of injury to basketball players' heels and knees. Therefore, to prevent heavier muscle damage when performing Plyometric Rim Jump exercises, it is necessary to look for muscle damage parameters, which may be able to see changes in Creatine Phospinase Levels enzyme levels [14]. To find out how much the predominant physical components (leg and arm muscle strength, leg and arm muscle explosiveness and flexibility) increase for basketball players to be able to perform and not get injured while doing both Plyometric Depth Jump and Rim Jump exercises, it can be determined by measuring: leg muscle strength with leg dynamometer, leg muscle power with vertical jump test, flexibility with fleximeter and to find out if there is damage to the muscles is measured by measuring serum Creatine Phospinase Levels in the blood. Based on the description above, the central theme can be compiled as follows: plyometric training is an exercise method used by basketball coaches to increase the explosiveness, muscle strength and flexibility of basketball players. Popular types of plyometric exercises used in basketball are; Plyometric depth jump and rim jump exercises. There are differences based on the movement patterns of the two training methods. In plyometric depth jump exercises carried out using plyometric box jumps, the load received by the leg muscles is greater (can reach seven times body weight), while in plyometric rim jump exercises the movement pattern is carried out only by making repeated jumps to the basketball hoop. It is not yet known which of these two forms of exercise can increase leg muscle explosiveness, muscle strength and greater flexibility but avoid the risk of injury.

METHOD

This type of research is a type of experimental research with a pretest and posttest design followed by a blood test in the laboratory. The research subjects were taken from a population of 28 basketball club players of the State University of Jakarta, which then the basis for sampling was using the Total Sampling technique. So that the sample in this study amounted to 28 samples and then it was randomly carried out by lottery and 2 groups of plyometric depth jum and plyometric rim jump exercises were obtained with each group totaling 14 people. Data collection techniques in this study use observation, and questionnaires. The instruments of this study were variable leg muscle strength using a leg dynamometer, leg muscle flexibility using a flexometer using the sit and reach test method and tugkai muscle explosiveness using the Vertical Jump method. The data analysis technique used in this study is to use ANACOVA with the help of SPSS 26. Before that, prerequisite tests were carried out, namely: (1) normality test and (2) homogeneity test. And ended the Hypothesis Test to find the final result of this research.

RESULT AND DISCUSSION

Result

1. Research Description

The physiological physical characteristics of the study subjects are in the form of age (years), weight (kg), height (cm), body mass index (kg/m2), resting pulse, systole and diastole blood pressure (mmHg) which are listed in the table below.

Table 1: Physical Physiological Characteristics of Research Subjects

Physiological Physical Characteristics	Group	n	X	±	sd	P
Age (year)	Depth Jump Exercise	14	20,07	±	1,27	0,335
	Rim Jump Exercise	14	20,71	±	2,09	
Sistole (mmHg)	Depth Jump Exercise	14	117,86	±	4,26	0,676
	Rim Jump Exercise	14	117,14	±	4,69	
Diastole (mmHg)	Depth Jump Exercise	14	77,14	±	6,11	1,000
	Rim Jump Exercise	14	77,14	±	6,11	
Pulse Rest	Depth Jump Exercise	14	76,50	±	6,10	0,277
	Rim Jump Exercise	14	73,93	±	6,16	
Height (cm)	Depth Jump Exercise	14	173,29	±	5,65	0,892
	Rim Jump Exercise	14	173,00	±	5,37	
Weight (kg)	Depth Jump Exercise	14	65,29	±	7,11	0,870
	Rim Jump Exercise	14	64,79	±	8,82	
Body Mass Index (kg/m2)	Depth Jump Exercise	14	21,66	±	1,30	0,922
	Rim Jump Exercise	14	21,60	±	2,07	

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Furthermore, to find out the difference in physiological characteristics between the two experimental groups (plyometric depth jump and rim jump training group) was carried out with an unpaired t-test ($p<0.05$), the results showed that there was no difference in physiological physical characteristics between the plyometric depth jump training group and the plyometric rim jump training group.

2. Prerequisite Test

The results of the measurement of Leg Muscle Explosiveness (cm), Leg Muscle Strength (Kg), Leg Flexibility (cm) and Creatine Phospinase Levels (U/L) of basketball players are listed in appendix 2. Furthermore, the results of the measurement were carried out a normality test with Shapiro-Wilk ($p>0.05$) and a variance homogeneity test with Levene's test ($p>0.05$), the results showed normal and homogeneous distributed data as listed in the table below.

Table 2: Normality Test

Data Normality Test	Group	Pre Test		Post Test	
		Shapiro-Wilk	p	Shapiro-Wilk	P
Leg muscle power	Depth Jump Exercise	0,856	0,027	0,907	0,141
	Rim Jump Exercise	0,918	0,208	0,928	0,286
Leg muscle strength	Depth Jump Exercise	0,967	0,839	0,923	0,246
	Rim Jump Exercise	0,959	0,702	0,958	0,691
Leg flexibility	Depth Jump Exercise	0,933	0,336	0,935	0,353
	Rim Jump Exercise	0,961	0,746	0,958	0,683
Creatine Phospinase Levels	Depth Jump Exercise	0,675	0,000	0,867	0,038
	Rim Jump Exercise	0,758	0,002	0,659	0,000

Table 3: Homogeneity Test

Variance Homogeneity Test	Group	Pre Test		Post Test	
		Levene's tets	P	Levene's tets	P
Leg muscle power	Depth Jump Exercise	0,725	0,402	0,453	0,507
	Rim Jump Exercise				
Leg muscle strength	Depth Jump Exercise	0,320	0,577	0,011	0,916
	Rim Jump Exercise				
Leg flexibility	Depth Jump Exercise	0,589	0,450	0,088	0,769
	Rim Jump Exercise				
Creatine Phospinase Levels	Depth Jump Exercise	2,166	0,153	1,465	0,237
	Rim Jump Exercise				

3. Hypothesis Test

The results of the homogeneity test of the variance of the research data all showed homogeneous data variance. Thus, hypothesis testing is carried out by parametric testing, namely by conducting an anacova test to determine the difference in influence before and after treatment and to find out the difference.

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Table 4: Effect of Plyometric Depth Jump Training with Plyometric Rim Jump Training on the Explosive Power of Basketball Players' Leg Muscles

Variable	Plyometric depth jump training		Plyometric rim jump training		Anacova	P
	x	sd	x	sd	F-Test Statistics	
Pre leg muscle explosiveness	54,71	5,40	54,86	6,62	0,004	0,951
Post leg muscle explosiveness	60,50	5,35	58,86	6,33	11,66	0,002
t-paired	15,203		11,015			
P	0,000		0,000			
Pre and Post test	5,786		4,000			
Percentage	9,56%		6,80%			
Conclusion	A		b			

Table 5: Effect of plyometric depth jump training with plyometric rim jump training on leg muscle strength of basketball players

Variable	Plyometric depth jump training		Plyometric rim jump training		Anacova	P
	X	sd	X	sd	F-Test Statistics	
Pre leg muscle strength	136,21	12,45	132,5	14,8	0,517	0,479
Post leg muscle strength	152,71	13,77	143,9	14,4	10,04	0,004
t-paired	12,153		13,479			
P	0,000		0,000			
Pre and Post test	16,500		11,357			
Percentage	10,80%		7,89%			
Conclusion	A		B			

Table 6: Effect of Plyometric Depth Jump Training and Plyometric Rim Jump Training on Basketball Players' Leg Flexibility

Variable	Plyometric depth jump training		Plyometric rim jump training		Anacova	P
	X	sd	x	sd	F-Test Statistics	
Pre Flexibility of the leg	17,89	1,64	18,81	1,95	1,798	0,192
Post Flexibility of the leg	19,32	1,90	19,71	1,91	10,45	0,003
t-paired	11,262		9,048			
P	0,000		0,000			
Pre and Post test	1,429		0,907			
Percentage	7,39%		4,60%			
Conclusion	A		B			

Table 7: Effect of Plyometric Depth Jump Training with Plyometric Rim Jump Training on Creatine Phospinase Levels of Basketball Players

Variable	Plyometric depth jump training		Plyometric rim jump training		Anacova	P
	X	sd	x	sd	F-Test Statistics	
Pre Creatine Phospinase Levels	237,6	146,1	356,3	214,2	2,935	0,099
Post Creatine Phospinase Levels	329,4	182,9	226,4	148,6	9,59	0,005
t-paired	3,286		-2,478			
P	0,006		0,028			
Pre and Post test	91,821		-129,929			
Percentage	27,88%		-57,40%			
Conclusion	A		b			

DISCUSSION

Fast-twitch muscle fibers are synonymous with rapid muscle contraction and low resistance to fatigue [15]. In addition to rapid muscle contraction, in fast-twitch muscle fibers the amount of calcium released by the sarcoplasmic reticulum is faster and the activity of an enzyme (myosin-ATPase) that breaks down ATP inside the head of myosin (the head part of the contractile protein) is more. This is suspected to have increased after doing regular plyometric depth jump and rim jump exercises. In addition, there is also an increase in myoglobin, oxidative enzymes, as well as the size and number of mitochondria in the muscles. There is an increase in the explosive power of the leg muscles because the movement pattern of plyometric exercises is a movement pattern dominated by the contraction of fast-twitch muscle fibers [16]. A combination of stretching and shortening muscle movements that are performed quickly, occurs when doing plyometric depth jump and rim jump exercises.

Myoglobin contained in muscles functions to bind oxygen, with regular physical activity will increase the amount of myoglobin by 13% - 14% so that the ability of muscles to bind oxygen will also increase. Furthermore, this will cause the size and number of mitochondria to increase as an energy-producing machine ATP in the cell. The more oxidative enzymes in the mitochondria, the more oxidative activity occurs in the muscles, so the amount of ATP produced will be more and the explosive capacity of the muscles can increase.

There is an increase in leg muscle strength after participating in plyometric depth jump and rim jump exercises due to hypertrophy of muscle fibers, an increase in myoglobin, an increase in oxidative enzymes in muscle sarcoplasmics and an increase in the number of mitochondria [17]. Plyometric depth jump and rim jump exercises include exercises that use inner load weights that aim to increase the explosive power of the leg muscles by combining the strength and speed of the leg muscles [18]. In performing plyometric depth jump and rim jump exercises, when both feet land on the floor after performing a vertical jump, the body's weight is placed on the leg muscles. The load that the leg muscles have to accept exceeds the actual body weight caused by the gravitational force of the earth [19]. The amount of load is overcome by the muscles by involving more motor units so as to increase the muscle fibers involved in performing muscle contractions, this is what causes an increase in muscle strength and explosive leg muscles in plyometric depth jump exercises and plyometric rim jump exercises. Repeating the plyometric dept jump and rim jump exercises has an impact on increasing the number of contractile proteins, increasing capillary density, myoglobin count, mitochondrial count, oxidative enzymes, myosin filaments and increasing the strength of connective tissue and ligaments around the muscles, this causes muscle hypertrophy.

There is an increase in leg flexibility after doing plyometric depth jump and rim jump exercises because plyometric deth jump and rim jump exercises are two forms of training methods that maximize the ability of the leg muscles to perform eccentric contractions followed by concentric contractions (SSC) in a very fast time. [20] revealed that the effect of stretching the muscles greatly determines the explosive power of these muscles when performing plyometric depth jump and rim jump exercises, leg flexibility is necessary to produce maximum vertical jumps. The repetition of movements in plyometric depth jump and rim jump exercises will have an impact on the musculotendon stretch ability of the leg joints and hamstring tendons thereby increasing the ROM (Range of Motion) of the leg and increasing the vertical jump ability of basketball players, this is what increases the flexibility ability of basketball players' legs [21].

However, a different thing happened in the group that was given plyometric depth jump training because there was a better increase in increasing leg muscle explosiveness, leg muscle strength and leg flexibility in this group compared to the plyometric rim jump training group in the results of the study that has been described earlier. This can be explained because in plyometric depth jump training the weight that the body has to receive is greater (up to seven times the body weight when the feet touch the floor), so it involves more muscle fibers to cope with the load, resulting in greater muscle hypertrophy [22].

This can be explained because the greater load increases the increase in the number of contractile proteins, increases the density of capillaries, the number of myoglobins, the number of mitochondria, oxidative enzymes, myosin filaments and increases the strength of connective tissue and ligaments around the muscles and the occurrence of mycotrauma in muscle cells [23].

The microtrauma that occurs then stimulates the muscles to grow back in response to the training load, adding filaments and increasing muscle volume to cope with the training load, this is what causes the increase in leg muscle explosiveness, leg muscle strength and leg flexibility in plyometric depth jump training compared to plyometric rim jump training.

An increase in Creatine Phospinase Levels in the blood after participating in plyometric depth jump training occurs because plyometric depth jump is a form of exercise that combines concentric and eccentric contractions in the leg muscles performed with high intensity and with explosive movements [21]. Movements that are carried out continuously with high intensity result in mechanical stress on muscle fibers [24].

Submaximal load usually affects structural reorganization, while supramaximal stimulus often causes cytoskeleton tissue rupture [25]. The existence of mechanical stress results in intraslular changes due to excessive strain and rupture of the sarcomer causing the release of Creatine Phospinase Levels from muscle cells into the blood circulation which can be indicated as muscle injury.

In addition, because the movement patterns in plyometric depth jump and rim jump exercises are carried out in a short time, the predominant energy source that supplies this activity is the energy source that comes from anaerobic metabolism, alktic acid and lactation. In alacic anaerobic metabolism, there is the enzyme Creatine Phospokinase which acts as a catalyst to produce ATP from creatine phosphate during maximum muscle contraction in a short time. In the anaerobic metabolism of lactation lactic acid is formed as production during the anaerobic metabolism of lactation.

In plyometric depth jump and rim jump exercises that are carried out with high intensity and predominant lactate metabolism causes an increase in lactic acid in muscle cells which results in sarcomer damage so that Creatine Phospinase Levels enzymes come out of muscle cells and circulate in the blood circulation, serum levels of skeletal muscle enzymes are markers of tissue physiological status and the occurrence of damage to skeletal muscle [26].

This is in accordance with the opinion of experts that the high increase in serum Creatine Phospinase Levels in the blood circulation depends on sarcomic damage, both caused by high-intensity exercise and muscular pathology and high-intensity exercise can increase skeletal muscle cell damage at the level of sarcolema and Z-line resulting in an increase in Creatine Phospinase Levels levels, this is what causes an increase in CPK levels in plyometric depth jump and rim jump training [27].

The high of Creatine Phospinase Levels after doing plyometric depth jump training compared to plyometric rim jump training can be explained because in plyometric depth jump training, the body weight transferred to the leg muscles when the feet touch the floor can reach seven times the body weight so that the load received is greater so that greater microtrauma occurs compared to plyometric rim jump training [28].

This is in accordance with the opinion of experts, that when the intensity of exercise is increased from light to moderate, muscle tissue does not experience changes in membrane permeability, but if the intensity of exercise continues to increase, muscle tissue can experience changes in permeability and enzyme release [29]. When the intensity of the exercise load increases beyond the limits of muscle ability, Creatine Phospinase Levels exits the muscle cells into the interstitial fluid which is then absorbed by the lymphatic system and circulates in the bloodstream, which is what causes a higher increase in CPK levels in plyometric depth jump training compared to plyometric rim jump training.

A different thing happened in the plyometric rim jump training group. In the plyomteric rim jump exercise group, there tends to be a decrease in Creatine Phospinase Levels levels in the blood after doing plyometric rim jump exercises. The decrease in Creatine Phospinase Levels levels that occurred in the plyometric rim jump training group can be explained because from the movement pattern performed, the intensity of plyometric rim jump training is lower compared to plyometric depth jump training.

In the plyometric rim jump training group, the movement pattern carried out is the repetition of jumps using one's own body weight, in contrast to the plyometric depth jump exercise movement pattern which can range from seven times the body weight when the basketball player gets off the plyometric box. This is supported by the results of the study which revealed that there was a decrease in Creatine Phospinase Levels levels after doing plyomteric rim jump exercises.

CONCLUSION

Based on the results of the above study, it can be concluded that plyometric depth jump training is better than plyometric rim jump training in increasing leg muscle explosiveness, muscle strength, flexibility and higher in increasing the level of creativity of Creatine Phospinase Levels basketball players. However, there was a decrease in Creatine Phospinase Levels levels after doing plyometric rim jump exercises. Some other factors that affect the level of Creatine Phospinase Levels expenditure after doing exercise are the duration and intensity of exercise.

The decrease in Creatine Phospinase Levels after plyometric rim jump training is likely due to excessive training adaptation which causes an increase in muscle strength and low exercise intensity so that there is minimal damage to the Z-line and sarcoloma. So that if you exercise regularly or people who are trained do not experience a significant improvement after doing exercises when compared to untrained people.

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