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THE EFFECT OF PLYOMETRIC TRAINING PROGRAM ON PHYSICAL PERFORMANCE IN BASKETBALL PLAYERS

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Abstract:
The aim of this study is to examine the effect of a plyometric training program on the physical performance of basketball players. 24 male basketball players between the ages of 18-36, who regularly practice basketball, participated in the study voluntarily. Participants were divided into two different groups as the experimental group (n=12, age: 26.50±4.58) and the control group (n=12, age: 22.32±0.90). A plyometric training program was applied to the experimental group 3 days a week for 6 weeks. Both participating groups continued their regular basketball training during the season. In addition to basketball training in the experimental group; Plyometric exercises known as Lateral jump, Box jump, Squat jump, Nordic hamstring curl, Overhead slam, Plyometric push-ups, and Medicine ball bench press were applied. Flexibility, balance, vertical jump, shuttle run test, speed, and T-test were measured before and after the training. SPSS 22.0 package program was used for the statistical analysis of the data. The Shapiro-Wilk test was used for the normality test. Paired Samples T-test was used for comparisons within groups. The significance level was determined as $p<0.05$. Significance was found in the flexibility, balance, vertical jump, shuttle run, speed, and T-test values of the experimental group ($p<0.05$). The values of the control group were not significant ($p>0.05$). As a result, it can be said that the 6-week plyometric training program applied to basketball players has a positive effect on physical performance.

Keywords: basketball, plyometric training, physical performance

1. Introduction

The aim of all sports branches in the world is to improve the physical parameters and performance of the athlete through training. The basketball branch is a team sport that includes coordination, and mixed and combined movements and requires skill.

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Therefore, important abilities such as strength, endurance, explosive strength, speed, and quick strength are the basic factors that must be present in basketball (1, 2).

In all sports branches, the training duration, intensity, and energy system are required to differ. It requires regular measurement and evaluation of the physiological and functional parameters of the body systems required by the sports branch for an effective training program. Basketball is a team sport that develops physical characteristics such as strength, coordination, endurance, speed, agility, and skill, starting from adolescence, in a purposeful and desired way, and consolidating it into adulthood (3). In the fast-paced and intense basketball season, there is little time to do extra training to gain strength and power. During a long and tiring basketball season, players are often too tired and reluctant to weight training. On the other hand, strength training brings with it financial burdens such as facilities, materials, and supplements for athletes and sports clubs. Therefore, there is a need for different training methods that are suitable and reliable to effectively improve jumping performance (2).

The training aimed at developing strength, speed, and explosive strength is defined as plyometric training (4). For sportive performance in basketball, motor skills such as balance, speed, jump, change of direction, and quickness must be at a high level. Plyometric training is a program that improves the athlete's maximal strength, explosive strength, speed, and anaerobic power (5, 6). The plyometric training program can contribute positively to basketball players with effective muscle contractions. Adding plyometric exercises can be considered an alternative training method in basketball.

The aim of this study is to examine the effect of the 6-week plyometric training program on the physical performance of basketball players and to make suggestions to trainers and athletes for training planning.

2. Methods

2.1. Subjects

A total of 24 male basketball players between the ages of 18-36, who regularly practice basketball, participated in the study voluntarily. Participants were divided into two different groups the experimental group (n=12, age: 26.50±4.58) and the control group (n=12, age: 22.32±0.90). Both participating groups continued their regular basketball training during the season. In addition to normal basketball training, the plyometric training program was applied 3 days a week to the experimental group for 6 weeks. Flexibility, balance, vertical jump, shuttle run, speed, and T-test were measured before and after the plyometric training.

2.2. Plyometric Training Program

In our study, the experimental group; in addition to basketball training, a plyometric training program for the lower and upper extremities were applied 3 days a week on the specified days for 6 weeks. Plyometric exercises known as Lateral jump, Box jump, Squat jump, Nordic hamstring curl, Overhead slam, Plyometric push-up, and Medicine ball

bench press were applied to the experimental group. In plyometric training, exercises were applied as 2*14 (set*repeats) in the first 2 weeks, 2*16 in the second 2 weeks, and 3*20 in the last 2 weeks (7, 8). A rest period of 20 seconds was given between repetitions and 1 minute between sets. A 10-minute warm-up period was given before starting the plyometric exercises.

2.3. Height, Body Weight, and BMI Measurements

The body weights of the subjects were measured with a scale with 0.1 kg precision, and their heights were measured with a digital height measuring device. BMI measurements were found by dividing the square of the height in meters by the body weight (9).

2.4. 20 Meters Speed Test

It is a test that is required to run at a maximal speed in a 20 m running field where speed is measured. The subjects were given an active warm-up period of 10 minutes before the measurement. During the measurement, when the subject felt ready 1 m behind the starting line, they were asked to exit. During the test, the subjects were given a 3-minute rest break and 2 trials were performed. At the end of the test, the best score was recorded for evaluation (9).

2.5. Flexibility Test

Flexibility was measured using the sit and reach test. It was explained to the participants how the measurement would be done with an oral explanation. Subjects sit on the floor with bare feet and rest their soles flat on the coffee table. They were asked to reach towards the measurement ruler from a sitting position with their legs placed towards the floor in a straight position, arms up, and 2 seconds. The best value was recorded from two measurements with waiting (9).

2.6. Flamingo Balance Test

Balance measurements of the subjects were measured with the Flamingo balance test. After the oral explanation, the subjects tried to stay balanced for 1 minute by getting on a 50 cm long, 4 cm high, and 3 cm wide application board. If the balance is disturbed and contact with the ground or bent leg and hand contact occurs, the time was recorded by stopping and the time was resumed by taking the position again. When the time was up, each attempt at balancing was counted and recorded as a score (10).

2.7. Vertical Jump Test

The test was performed on a flat surface using a measuring meter and clipboard and a pen. The subjects were verbally explained how to make the measurement. His legs were shoulder-width apart, close to the open wall, and he was asked to mark with the pen in hand until the last point he could reach vertically in a single move. The distance between the first reach and the jump was recorded in cm. Three attempts were made and the best score was recorded (9, 11).

2.8. Shuttle Run Test

Shuttle Run test is a measurement in which aerobic capacity is tested. The measurement content was verbally explained to the subjects. For the measurement, a test cassette was used with a distance of 20 m and a speed of 0.5 km/h for every 60 seconds with the audible signal. At the end of each signal, one foot of the athlete was asked to meet the line at the end of the 20 m distance. The subject was asked to stop the measurement after three stimulations. The test was continued until the athletes were tired (9).

2.9. T-test

The purpose of the measurement and how it will be done were verbally explained to the athletes. A timer, funnel and a non-slip flat surface was used for this test, which is used to measure the quickness of reaction. A T-shaped area of 10 m long and 10 m wide was created. In the starter portion, the participant, who was asked to come out when ready, was asked to do the series in different directions and shapes in the fastest time. The test ended with forward running, sliding to the right and left directions, and running backward and the scores were recorded (12, 13).

2.10. Statistical Analysis

The statistical data of this study were analyzed with the SPSS 22.0 statistical analysis program. Before statistical operations, Shapiro-Wilk Test was applied to determine whether the data were normally distributed. Paired Samples T-Test was used for in-group comparisons. Statistical data were evaluated at $p<0.05$ significance level. The G Power 3.1 program was used to determine the number of subjects participating in the study.

3. Results

Table 1: Descriptives

Variable	**Experimental Group**	**Control Group**
	Mean±SD	**Mean±SD**
Age (years)	26,50±4,58	22,32±0,90
Height (cm)	1,96±0,10	1,88±0,08
Weight (kg)	95,43±13,78	83,92±9,28
BMI (kg/m^2)	24,30±2,67	23,16±1,09

Descriptive information of the experimental and control groups are given in Table 1.

Table 2: Pre-test and post-test analysis results of the experimental group

Variable	Pre-test (df:11)	Post-test (df:11)	t	p
	Mean±SD	Mean±SD		
Flexibility (cm)	36,42±4,42	39,67±3,93	-8,298	**0.000***
Flamingo balance test	6,33±1,82	3,67±1,77	14,182	**0.000***
Vertical jump (cm)	56,92±5,51	61,92± 4,12	-8,124	**0.000***
20 m shuttle run test	90,42±7,15	93,17±6,63	-4,861	**0.001***
Speed 20 m (sec)	3,48±0,28	2,98±0,18	7,734	**0.001***
T-test (sec)	11,07±0,73	9,88±0,35	7,285	**0,000***

*p<0.05

In Table 2, the comparison of the pre-test and post-test measurement results after the plyometric training program was applied to the experimental group is given. Statistically, significance was found in the flexibility, flamingo balance test, vertical jump, 20 m shuttle run test, and T-test values of the experimental group (p<0.05).

Table 3: Pretest and posttest analysis results of the control group

Variable	Pre-test (df:11)	Post-test (df:11)	t	p
	Mean±SD	Mean±SD		
Flexibility (cm)	35,92±7,60	36,17±7,74	-1,393	0,191
Flamingo balance test	8,00±1,27	7,75±1,138	1,149	0,275
Vertical jump (cm)	40,67±3,28	42,08±3,11	-3,027	0,012
20 m shuttle run test	79,58±11,19	80,50±12,33	-0,875	0,40
Speed 20 m (sec)	3,19±0,18	3,18±0,16	1,529	0,15
T-test (sec)	10,48±0,34	10,31±0,30	1,520	0,15

In Table 3, the comparison of the first and last test measurement results of the control group is given. No significance was found in the control group parameters (p>0.05).

4. Discussion

In our study, a significant difference was found in flexibility, balance, vertical jump, 20 m shuttle run test, 20 m speed, and T-test values after the 6-week plyometric training program applied to the experimental group (p<0.05). No significance was found in the control group parameters (p>0.05).

Flexibility depends on factors such as joint structure, muscle structure, muscle mass, joint capsule, and intramuscular and intermuscular coordination. Along with strength and power training, muscle and intermuscular coordination develop, and strength increases (14). In our study, a p<0.05 level of significance was found in the flexibility values of the experimental group after the plyometric training program. Plyometric exercises positively affect intermuscular and intramuscular coordination. The important reason for the positive improvement in flexibility parameters as a result of plyometric training is the development of muscle and intramuscular coordination (2). In a study, it was determined that there was a statistically significant improvement in

flexibility values after the plyometric training program was applied to football players (7). An increase in flexibility values was determined after an 8-week plyometric training program was applied to taekwondo athletes (15). In a study conducted with young athletes, it was stated that 10-week plyometric training had a positive effect on flexibility in athletes (16). In a study conducted on young football players, a positive improvement was found in the flexibility values of the athletes after plyometric training (17). In the literature, it is generally stated that plyometric exercises improve flexibility. It is thought that the flexibility development in the experimental group in our study is due to the positive interaction between the intramuscular and the muscles as a result of the plyometric training.

In our study, a significant difference was found in the balance scores after the plyometric training program was applied to the experimental group ($p<0.05$). No significant difference was found in the parameters of the control group ($p>0.05$). Balance is extremely important in the realization of physical activities and sports skills (18). In a study conducted with young athletes examining their jumping performance, it was concluded that plyometric training positively affected the balance parameter (16). In another study, it was observed that with the content of plyometric exercises applied to young basketball players, the balance and quick strength of the athletes increased, and it was argued that similar studies were applicable (19). Majeed et al. (2016) found that there was a significant difference in the dynamic balance of badminton athletes after six weeks of plyometric training (20). In another study, an improvement was found in balance performance after plyometric training was applied to volleyball players (21). Studies in the literature generally show that balance scores increase after plyometric training. It is thought that the significant difference in the balance scores of the experimental group in balance measurements in our study is due to the increase in intermuscular and intramuscular muscle interaction with the development of muscle strength of the plyometric exercises performed by the athletes together with basketball training.

Since jumps are made in a very small-time interval in plyometric studies, it provides the development of both explosive features and explosive power (9). In our study, a significant difference was found in the vertical jump values after the plyometric training program was applied to the experimental group ($p<0.05$). Adams et al. (2001), in their study examining the effects of plyometric training on vertical jump, found an increase in vertical jump performance (22). Durham et al. (2001), in their study examining the anaerobic effects of plyometric studies on the lower body extremities, found that the groups increased the number of jumps and the mean jump heights (23). In another study, they found a significant increase in the anaerobic power parameters of the athletes at the end of the plyometric training performed in elite athletes (24). The values found in our study are similar to the studies in the literature. In our study, it can be said that the increase in the vertical jump values of the experimental group was due to the development of muscle strength in the plyometric training they performed.

In this study, a significance level of $p<0.05$ was found in the 20 m Shuttle Run test values of the experimental group. Among the factors that positively affect sportive

success in long-term and high-intensity physical activities, endurance has an important place (25). Öztin et al. stated that plyometric training had a positive effect on the shuttle run parameters (26). Çavdar stated in his study that there were significant differences in all strength and endurance data (16). In a study conducted on football players, an increase was found in endurance values after plyometric training (17). Studies in the literature are similar to our research. It is thought that the significant difference in the 20 m Shuttle Run test values in our study is due to the improvement of the endurance parameter of the basketball trainings performed by the subjects regularly.

In our study, a significance level of $p<0.05$ was found in the speed values of the experimental group after the 6-week plyometric training program. No significance was found in the speed data of the control group. Speed ability is a complex sport-specific feature. It is known that speed depends on genetic factors and is an important factor for sportive performance (27). In a study on basketball players, it was determined that plyometric training in water and on land positively affects sprint performance (28). In another study, significant positive improvements were found in the 20 m sprint performance of the subjects as a result of strength training combined with plyometric training (29). There are other studies in the literature in which plyometric training improves sprint performance (17, 30). Our study is in parallel with the information given in the literature. It is thought that the increase in speed in the experimental group in our study is due to the plyometric exercises and nerve-muscle interaction in addition to the regular basketball training.

The significance level of $p<0.05$ was found in the T-test values of our experimental group after the 6-week plyometric training program in our study. In a study, high-intensity plyometric exercise for 6 weeks was found to improve agility and agility in athletes (31). Sukumar et al. (2017) found that plyometric training applied to athletes aged 16-18 greatly improved agility performance (32). Our study is similar to the studies in the literature. It can be said that the increase in T-test values in the experimental group in our study is the result of plyometric training applied together with regular basketball training.

As a result, it can be said that the 6-week plyometric training program applied to basketball players has a positive effect on physical performance. Since regular and planned plyometric training will have a positive effect on physical performance, it may be recommended to add plyometric exercises to basketball training planning.

Conflict of interest

There are no potential conflicts of interest between the authors of this article.

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