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The Effect of Plyometric Training Combined with Electrical Muscle Stimulation on Sports Performance Parameters in Basketball Players

Basketbolcularda Elektriksel Kas Uyarımı ile Birleştirilmiş Pliometrik Antrenmanın Sportif Performans Parametrelerine Etkisi

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THE EFFECT OF PLYOMETRIC TRAINING COMBINED WITH ELECTRICAL MUSCLE STIMULATION ON SPORTS PERFORMANCE PARAMETERS IN BASKETBALL PLAYERS

ABSTRACT

Today, there are various training methods used to increase athletic performance. One of these methods is artificial electrical muscle stimulation (EMS) used as strength maintenance and development training. The objective of the study is to examine the effects of plyometric training applications combined with EMS on sportive performance in basketball players. A total of 20 basketball players between the ages of 15-20 participated in the research. Participants were randomly divided into two equal groups: plyometric (PA) and plyometric training combined with EMS (PEMS). At the beginning and end of the study, the participants' height, body weight, vertical jump, 20m sprint, agility, balance and repeated sprint performance measurements were taken. In the findings of the study, there was a statistically significant difference between the pre-test and post-test scores of the PEMS and PA groups, among all sportive performance parameters. However, it was determined that there was no statistically significant difference between the groups in vertical jump, balance, agility, 20m sprint and repeated sprint performances. As a result, it can be said that both plyometric training and EMS training combined with plyometric training are two effective methods that can be used to improve sportive performance.

Keywords: *Basketball, Electrical Muscle Stimulation, Performance, Plyometric Trainin.*

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BAŞLIK BASKETBOLCULARDA ELEKTRİKSEL KAS UYARIMI İLE BİRLEŞTİRİLMİŞ PLİOMETRİK ANTRENMANIN SPORTİF PERFORMANS PARAMETRELERİNE ETKİSİ

ÖZ:

Günümüzde, sportif performansı artırmak için kullanılan çeşitli antrenman yöntemleri vardır. Bu yöntemlerden biri, kuvveti koruma ve geliştirme antrenmanı olarak kullanılan yapay elektriksel kas uyarılarıdır (EMS). Araştırmanın amacı basketbolcularda elektriksel kas uyarımı (EMS) ile birleştirilmiş pliometrik antrenman uygulamasının sportif performans parametrelerine etkilerini incelemektir. Araştırmaya 15-20 yaş arasında toplam 20 basketbolcu katıldı. Katılımcılar pliometrik (PA) ve EMS ile birleştirilmiş pliometrik antrenman (PEMS) olmak üzere rastgele iki eşit gruba ayrıldı. Araştırmanın başında ve sonunda katılımcıların boy

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uzunluğu, vücut ağırlığı, dikey sıçrama, anaerobik güç, 20m sürat, çeviklik, denge ve tekrarlanan sprint performans ölçümleri alındı. Araştırmanın bulgularında PEMS ve PA gruplarının ön test son test skorları arasında tüm sportif performans parametreleri arasında istatistiksel olarak anlamlı bir fark olduğu saptandı. Ancak, gruplar arasında dikey sıçrama, denge, çeviklik, 20m sürat ve tekrarlı sprint performanslarında istatistiksel olarak anlamlı bir fark olmadığı belirlendi. Sonuç olarak hem pliometrik antrenmanlar hem de pliometrik antrenman ile birleştirilmiş EMS antrenmalarnı sportif performansı geliştirmede kullanılabilecek iki etkili yöntem olduğu söylenebilir.

Anahtar Kelimeler: *Basketbol, Elektriksel Kas Uyarımı, Performans, Pliometrik Antrenman.*

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INTRODUCTION

Electrical muscle stimulation (EMS) applications are based on sending external stimuli to the muscles and nerves through electrodes placed on the skin. These electrical stimuli cause an involuntary contraction in the muscle by creating direct action potentials with the depolarization of the motor neurons and indirect action potentials with the depolarization of the sensory afferents (Siff, 1990; Peckham and Knutson, 2005), and it is aimed to improve the basic muscle properties by training the muscles with the help of repetitive contractions (Pichon et al., 1995; Maffiuletti et al., 2000).

It is known that studies on EMS date back to very old times. The first studies on EMS started in 1790 (Kırdı, 1998), and the EMS application, which developed in the historical process, was first used in sports in 1977 (Ward and Shkuratova, 2002). With the increase in EMS applications over time, studies have moved from local muscle EMS applications to whole body electrical muscle stimulation (WBEMS) applications (Indistan et al., 2019). The use of WBEMS applications in training has gained popularity especially in recent years (Fehr, 2011; Flipovic et al., 2012).

Although WBEMS technology is a fairly new technology, there are different forms of the device. However, in general, devices that can send stimuli to 14-18 regions or 8-12 muscle groups at the same time (quadriceps, hamstring, gluteus, erector spinea, latissium dorsi, trapezius, pectoralis, rectus abdominis, biceps, triceps) are used (Kemmler et al., 2016). It is known that the application of EMS technology combined with dynamic exercises plays a very important role in the development of athlete performance. This method is emphasized as the final point where technology and physical activity meet (Paillard, 2008; Yong-Seok, 2018).

When the studies in which different training methods were combined with EMS were examined, many studies were found (Willoughby and Simpson, 1996; Wirtz et al., 2015; Malatesta et al., 2003; Wirtz et al., 2016; Herrero et al., 2010; Voelzke et al., 2012; Maffiuletti et al., 2002; Herrero et al., 2006; Benito-Martínez et al., 2012; Martínez-López et al., 2012; Benito Martínez et al., 2013; Herrero et al., 2010). One of the most researched methods among these training methods is the plyometric training method (Maffiuletti et al., 2002; Herrero et al., 2006; Benito-Martínez et al., 2012; Martínez-López et al., 2012; Benito Martínez et al., 2013; Herrero et al., 2010). However, the main problem in studies on EMS applications combined with plyometric training is that EMS application is only applied to the lower part of the body. Therefore, how the performance of the athletes will be affected as a result of combining the WBEMS application and plyometric training applications is an important question waiting to be explained. In addition, when studies examining plyometric training combined with EMS were examined, it was determined that the jump and speed performances of the athletes were emphasized, but their balance, repetitive sprint and agility performances were not measured. In this context, the aim of the research is to determine the effects of plyometric training practices combined with WBEMS on athlete performance.

The hypothesis of this research is that PA applications combined with WBEMS will affect athlete performance more positively than only PA applications.

METHODS

Design of the Study

Randomized controlled experimental method, one of the quantitative research models, was used in this cross-sectional study. The study was conducted in accordance with the Declaration of Helsinki, after obtaining permission from the Inonu University Clinical Research Ethics Committee (2020/133). All participants voluntarily participated in the research. After signing the voluntary consent form, data were obtained from the participants over the age of 18. The parent volunteer consent form was obtained from the participants under the age of 18 after signing it. The study included 20 male athletes aged 15-20, playing basketball actively in the Stars League. Participants were randomly divided into two equal groups: plyometric (PA) and plyometric training combined with EMS (PEMS) (Table 2). Before the study, the familiarization phase was applied for two weeks in order for the participants to get used to the EMS and PA. After the practice phase, the exercises were performed for 12 weeks under the supervision of a leader with training knowledge.

Data collection

All measurements were taken twice, at the beginning and end of the study, between 10 and 11 a.m.

Height and Weight Measurement: At the beginning and end of the study, the height of the participants was measured with a wall-mounted stadiometer (Holtain Ltd. England), and their body weights were measured with an electronic scale (Seca, Germany). Height measurement was made without shoes. Weight measurement was taken between 8 and 9 o'clock in the morning after waking up without having breakfast.

Vertical Jump Test: The athletes were asked to stand with their feet shoulder-width apart. Athletes were asked to reach the highest point they could reach on the Vertec, this was considered the zero starting point. The athletes were asked to jump by bending their knees, hips and ankles without taking a step, and to touch the highest point they could reach on the vertec. The jumping distance heights of the athletes were determined by subtracting the highest distance reached in Vertec from the arm length distance (Michael and Robert, 2018).

Flamingo Balance Test: The flamingo balance test was applied to evaluate the static balance performance of the athletes. The athletes were asked to stand on the flamingo balance beam with their dominant leg. The athlete was asked to bend the other leg towards his hip by flexing it from the knee, and hold it with his hand and fix it. During the one-minute period, the timer was stopped each time the athlete lost balance. After each loss of balance, the athlete was asked to take the starting position. Afterwards, the time was resumed and each balance loss of the participant was evaluated as one point and recorded (Hazar, 2008).

Illinois Agility Test: A rectangular track with a width of 5 m and a length of 10 m was set up for the Illinois agility test. 8 funnels were used for the track. A total of 4 funnels were used to place one funnel at each corner of the rectangle. These funnels were named points A, B, E, and F, respectively. 4 funnels were placed between both short sides of the rectangle. The distance between the funnels in the middle was set as 3.3 m. The funnel placed between point B and E was named point D, and the funnel placed between point A and point F was named point C. Point A was set as the starting point. At the starting point, the athlete stood in the prone position. With the warning sound given to the athlete to start the test, the athlete got up and started the test. At the same time, the stopwatch was started with a beep. From the starting point, point A, the athlete started running and when he reached point B, he made his way back to point C. When he reached the C point, he turned around the funnel and advanced through the funnels with a slalom motion until the D point. When he reached point D, he turned back around the funnel and continued his slalom up to point C. He turned around the funnel at point C and continued the run to point E. When he reached point E, he made a turn again and then ran to point F and finished the test application. Stopwatch stopped when the athlete completed the test (Açak et al., 2012).

20m Sprint Test: The 20 m speed test was applied to measure the speed of the athletes. The 20 m sprint test was measured using a photocell (Smart Speed, Fusion

Sport, Queensland, Australia). For the test, 2 funnels were placed at the start and end points of 20 m. Before the test, the athletes were given information about the test protocol and a trial was made. Athletes performed the test 3 times at 2-minute intervals. The average values of their performance were calculated and recorded. In case the athletes could slow down before exceeding 20 m, another training funnel of different color was placed at 25 m and they were asked to run up to the hopper. Athletes started stationary right next to the starting line as the starting point (Açak et al., 2012).

Repeated Sprint Test: The athletes were asked to sprint 6 times at a distance of 20 m. Between sprints, the athletes were given 25 seconds to come back to the starting line. The averages of the 6 sprint performance values applied by the athletes were calculated and recorded. The repeated sprint test was measured using a photocell (Smart Speed, Fusion Sport, Queensland, Australia) (Fukuda, 2019).

TRAINING PROTOCOL

The training protocol (Miller et al., 2006; Özen et al., 2020) with and without EMS was applied two days a week for 12 weeks, apart from the routine training program. The exercise protocols started with a 10-minute warm-up period, followed by a main phase of 20-minute plyometric exercises and ended with a 10-minute cool-down at the end of the main phase. Training protocols were applied with 48-hour intervals to ensure adequate recovery (Özen et al., 2020). The plyometric training protocol applied is shown in Table 1.

The 20-minute fitness package of the EMS device (AQ8, Spain) was applied as the PEMS protocol. Electrical muscle stimulation was provided by giving stimulus to the muscles determined in the lower and upper extremities (quadriceps, hamstring, gluteus, erector spinea, latissium dorsi, trapezius, pectoralis, rectus abdominis, biceps, triceps) with electrodes attached to the EMS suit.

Table 1. Plyometric training program

Exercises	1-3 weeks (sets x reps)	4-6 weeks (sets x reps)	7-9 weeks (sets x reps)	10-12 weeks (sets x reps)
Ankle hops	3x8	3x10	3x12	3x14
Repeated long jump	3x8	3x10	3x12	3x14
Squat jump	3x8	3x10	3x12	3x14
Cone hops with 180 degree turn	3x8	3x10	3x12	3x14
Vertical power jump	3x8	3x10	3x12	3x14
Tuck jump	3x8	3x10	3x12	3x14
Box jump (40 cm)	3x8	3x10	3x12	3x14
Drop Jump (40 cm)	3x8	3x10	3x12	3x14
Total	168	210	252	336

2 minutes rest between sets

Statistics Analysis: Data were analyzed with the IBM Statistics (SPSS, ver. 26.0, Armonk, NY) program. The normality distributions of the data were tested with Shaphiro-Wilk's and Levene tests. Repeated measure ANOVA test was used to determine the differences within and between groups. Statistical significance level was accepted as $p<0.05$.

RESULTS

The findings obtained from the research are presented below.

Table 2. Descriptive Statistics of the groups

Group	Variables	n	Min.	Max.	Mean	sd
PEMS	Age (years)	10	15.00	20.00	17.90	2.02
	Height (cm)	10	171.00	206.00	187.70	10.65
	Weight (kg)	10	57.00	102.00	79.10	15.50
PA	Age (years)	10	15.00	20.00	17.10	1.79
	Height (cm)	10	172.00	192.00	179.60	5.87
	Weight (kg)	10	50.00	101.00	73.90	16.52

The mean age of the PEMS group was 17.90±2.02 years, the mean height was 187.70±10.65 cm, and the mean body weight was 79.10±15.50 kg. The mean age of the PA group was 17.10±1.79 years, the mean height was 179.60±5.87 cm, and the mean body weight was 73.90±16.52 kg (Table 2).

Table 3. Tests of Within-Subjects Effects Repeated Measure Anova Test Results

Variables		Group	Mean	sd	Sum of Squares	df	Mean Square	F	p	Effect Size
Vertical jump (cm)	Pre test	PEMPS	47	5.55	518.400	1	518.400	44.92	<0.001	0.71
		PA	48.30	6.05						
	Post test	PEMPS	54.90	4.30						
		PA	54.80	5.92						
Error					207.700	18	11.539			
20m Sprint (s)	Pre test	PEMPS	3.27	0.11	1.232	1	1.232	137.27	<0.001	0.88
		PA	3.38	0.19						
	Post test	PEMPS	2.92	0.17						
		PA	3.03	0.13						
Error					0.162	18	0.009			
Flamingo balance (rep/min)	Pre test	PEMPS	10.00	4.94	297.025	1	297.025	89.93	0.0004	0.83
		PA	13.80	7.17						
	Post test	PEMPS	5.60	4.45						
		PA	7.30	4.37						
Error					59.450	18	3.303			
Illinois agility (s)	Pre test	PEMPS	18.26	1.086	19.279	1	19.279	114.70	<0.001	0.86
		PA	18.50	1.096						
	Post test	PEMPS	16.97	0.96						
		PA	17.02	0.77						
Error					3.076	18	0.168			
Repeated sprint (s)	Pre test	PEMPS	3.64	0.18	3.499	1	3.499	115.79	<0.001	0.86
		PA	3.74	0.32						
	Post test	PEMPS	3.07	0.08						
		PA	3.12	0.1						
Error					0.544	18	0.030			

As a result of the Table 3, it was determined that there was a statistically significant difference between the pre-test and post-test values of jump, sprint, illinois agility, balance and repeated sprint variables in the participant groups (p<0,05).

Table 4. Tests of Between-Subjects Effects Repeated Measure Anova Test Results

Variables		Group	Mean	sd	Sum of Squares	df	Mean Square	F	p	Effect Size
Vertical jump (cm)	Pre test	PEMPS	47	5.55	4.900	1	4.900	0.425	0.523	0.023
		PA	48.30	6.05						
	Post test	PEMPS	54.90	4.30						
		PA	54.80	5.92						
Error					207.700	18	11.539			
20m Sprint (s)	Pre test	PEMPS	3.27	0.11	4.000	1	4.000	0.004	0.948	<0.001
		PA	3.38	0.19						
	Post test	PEMPS	2.92	0.17						
		PA	3.03	0.13						
Error					0.162	18	0.009			
Flamingo balance (rep/min)	Pre test	PEMPS	10.00	4.94	11.025	1	11.025	3.338	0.084	0.156
		PA	13.80	7.17						
	Post test	PEMPS	5.60	4.45						
		PA	7.30	4.37						
Error					59.450	18	3.303			
Illinois agility (s)	Pre test	PEMPS	18.26	1.086	0.870	1	0.087	0.520	0.480	0.028
		PA	18.50	1.096						
	Post test	PEMPS	16.97	0.96						
		PA	17.02	0.77						
Error					3.076	18	0.168			
Repeated sprint (s)	Pre test	PEMPS	3.64	0.18	0.008	1	0.008	0.250	0.623	0.014
		PA	3.74	0.32						
	Post test	PEMPS	3.07	0.08						
		PA	3.12	0.10						
Error					0.544	18	0.030			

As a result of the Table 4, it was determined that there was no statistically significant difference between the PEMS and PA groups' values of vertical jump, 20m sprint, illinois agility, flamingo balance and repeated sprint variables (p<0,05).

DISCUSSION

In this research, the effects of plyometric training and plyometric training combined with EMS on vertical jump, 20m sprint, agility, balance and repetitive sprint performances of basketball players were examined. As a result of this research, it was determined that plyometric training and plyometric training applications combined with EMS improved the vertical jump, 20m sprint, Illinois agility, static balance and repetitive sprint performances of young competitive basketball players (p<0.05), (Table 3). However, in the pairwise comparison of the PEMS and PA groups, it was determined that there was no statistical difference between the two training applications on 20m sprint, flamingo balance, Illinois agility, vertical jump and repetitive sprint scores (p<0.05), (Table 4).

It has been stated that the special training program can affect the performance of basketball player (Küçük et al., 2014). There are already many studies in the literature examining the effects of plyometric training, and almost all of these studies have shown that plyometric training is effective in the development of power, jump height, sprint performance and agility (Cheng et al., 2003; Ozbar et al., 2014; Yarayan and Müniroğlu, 2020). In the literature, the effectiveness of plyometric training is explained as follows. Plyometric exercises lead to the use of elastic properties of muscle fibers and connective tissues. They allow the muscle to store energy during the deceleration and stretching phases and to release that energy during the acceleration and contraction phases (Asmussen, 1974; Bosco et al., 1982; Kaneko et al., 1983). During the plyometric exercise, while the muscle is not exposed to resistance, the muscles that will work as agonists are then stretched and this initiates the stretch reflex over the muscle spindles. The stretch reflex transmits an increased stimulation to the muscle fibers that are not active at the moment, and thus the subsequent contraction is higher and faster (Kalyoncu et al., 2005). This muscle work forms the basis of plyometric exercises. However, in recent years, an answer has been sought to the question of whether more improvement in sportive performance can be achieved when plyometric training is combined with other methods. One of the most popular among these methods is the plyometric training method combined with EMS.

The EMS method can delay or prevent potential muscle atrophy by contracting the muscles through artificial stimuli. In fact, the main purpose of EMS is to strengthen the muscles by artificially providing muscle contractions similar to the contractions that occur during exercise (McGinnis, 2013). Thus, it is aimed to train the athlete and strengthen the basic muscle structure through repetitive contractions (Maffiuletti et al., 2000; Pichon et al., 1995). In addition, the EMS technique provides stimulation on the muscle structure, improving the weakened passive muscle tissues and activating the muscle fibers that are difficult to work with (Taşpınar, 2007).

When the literature on EMS training applications is examined, while the effect size on vertical jump performance has been examined in many studies, there are limited studies on sprint performance. In addition, no studies were found on agility and balance performances.

Plyometric training applications combined with EMS improve the jumping performance of exercisers (Herrero et al., 2006), volleyball players (Maffiuletti et al., 2002; Malatesta et al., 2003) and athletics (Martínez-López, et al., 2012). Likewise, based on the data of our research, it can be said that plyometric training applications combined with EMS positively affect the vertical jump performance of basketball players (Table 3; Table 4).

Plyometric training applications combined with EMS improve the sprint performance of exercisers (Herrero et al., 2006). In addition, strength training applications combined with EMS improve the sprint performance of tennis players (Maffiuletti et al., 2009). In another study, it was reported that gymnastic training practices combined with EMS improved the sprint performance of gymnasts. (Deley et al., 2011). Similarly, it has been reported that WB-EMS applications improve the sprint performance of elite football players (Filipovic et al., 2016) and lower extremity strength exercises combined with EMS improve sprint performance of volleyball players (Voelzke et al., 2012). Likewise, based on the data of our study, it was determined that plyometric training applications combined with EMS improved the sprint performance of basketball players (Table 3; Table 4).

In this study, it was also determined that plyometric training applications combined with EMS positively affected the agility, balance and repetitive sprint performance of basketball players (Table 3; Table 4). However, when EMS training applications are examined in the literature, it has been determined that there is no research on agility, balance and repetitive sprint performance. Nevertheless, there are many studies reporting that plyometric training practices improve agility, balance and repetitive sprint performance of athletes (Miller et al., 2006; Atacan, 2010; Akçınar, 2014; Şirin, 2020; Özgül, 2019; Alikhani et al., 2019; Ceylan, 216; Haghighi et al., 2012; Michailidis et al., 2013; Buchheit et al., 2010).

CONCLUSION

The age group of the participants being between 15 and 20, the sex of all participants being male and the sport branch of all participants being basketball were the limitations of the present study. In addition, the lack of a group that only applies EMS application in the research group is among the limitations of the study.

As a result of this research, it was determined that plyometric training combined with plyometric training and EMS improved the vertical jump, 20m sprint, agility, balance and repetitive sprint performances of basketball players. The fact that all sportive performance parameters of both groups were improved shows that both training methods are effective. In future studies, it is recommended to design studies with larger research groups and more groups. In addition, for future studies, it can be suggested that different training applications combined with EMS application be applied with different branch athletes. Also, it may be suggested to measure more different sportive performance parameters.

Conflict of Interest Statement

There is no personal or financial conflict of interest between the authors of the article within the scope of the study.

Researchers' Contribution Rate Statement

Design of the Research: İİ; MA

Data Collection: İİ

Statistical analysis: MA

Preparation of the Article: İİ; MA

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