



# The effect of plyometric training on performance levels of the shot put technique and its related motor abilities

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## Abstract

**Purpose:** The aim of this research is to evaluate the effects of plyometric training on the shot put technique. It was oriented to improve the basics for the development of power related-indicators such as power (explosive force), acceleration speed, and strength endurance.

**Material:** The study sample included 220 male students, aged 16 years  $\pm$  6 months from Fehmi Lladrovci High School, Glogoc municipality, Republic of Kosovo from the 2019/2020 academic year. The experimental group (110 male students) applied a 12-week program (see the training program paragraph). The control group (110 male students) continued only with their regular physical education lessons (2 times a week). To determine the differences between pre- and post-test values of the control and experimental groups ANOVA calculations were made. The development percentage in time (between pre-test and post-test) were calculated using the formula:  $\Delta\% = (x \text{ post-test} - x \text{ pre-test}) / \text{pre-test} * 100$ .

**Results:** Results of the study show that pre- and post-test average values (tests within subjects) of the shot put technique ( $p < 0.05$ ) were statistically different according to measurement over time (interaction;  $p < 0.05$ ), and in tests between the subjects ( $p < 0.05$ ). The shot put technique ( $\Delta\%: 50.88$ ) test of the experimental group (plyo-training) had higher developmental percentages compared to ( $\Delta\%: 1.69$ ) the control group ( $p < 0.05$ ). When analyzing the developmental percentage, it was observed that the performance of the shot put technique of the experimental group compared the control group 49.2% more developed. Furthermore, the impact of the plyometric training program in motor abilities related to the shot put technique also observed similar improvements in the impact of the shot put technique.

**Conclusions:** In conclusion, the impact of the plyometric training program on motor abilities related to the shot put technique also observed similar results as the training program's impact on the shot put technique. The applied plyometric training program benefits were not just in the shot put technique but also improved all motor abilities related to the shot put technique such as power, strength endurance, speed and acceleration. Therefore, the development of the shot put technique occurred by an increase in motor abilities related to the shot put technique as a result of the plyometric training program.

**Keywords:** shot-put technique, plyometric training, power (explosive force), acceleration speed, strength endurance

## Introduction

Athletics is an exclusive collection of sporting events that include races in running, jumping, throwing and walking. The most common types of athletics competitions take place on sports fields and also include street jogging, sports walking races, etc. Athletics is primarily an individual sport, with the exception of relay races and competitions, which combine team performance of athletes, or athlete scores, such as in cross-country [1].

Shot put is one of the four disciplines that are part of athletics throwing along with the discus throw, hammer throw and javelin. The shot put is an athletic throwing event that involves putting, or pushing, a heavy metal ball with one hand as far as possible. Shot putters use their strong quadriceps, hamstrings and gluteus maximus muscles to push off from the back of the circle and generate the initial thrust necessary to get the heavy metal shot moving across the circle.

Throwing involves an exact shot put technique based

on explosive actions such as short sprinting, jumping, weightlifting, etc. Plyometric exercises are mainly used to increase maximum energy production and the ability to jump. Plyometric training programs include training loads with a number of jumps and intervals between sets of exercises and drills. In plyometric exercises, athletes perform various explosive actions, which help to improve their skills [2, 3].

Depending on the effect on the neuromuscular system and their biomechanical structure, trainers have categorized strength-training exercises for throwers as general or specific [4, 5]. General exercises are those that aim to build a foundation by increasing maximum strength in specific muscles, especially the main movers, regardless of the range of motion, joint angle, or speed that may occur in the current event [6].

Performance on track and field throwing competitions depends to a large extent on the production of muscle power. Muscle power is a product of strength and speed, so each or both of these ingredients, should be addressed in a training program to develop muscle power. Both

groups of athletes, beginners and elite throwers, spend a great deal of their preparation using conventional power training or various forms of energy training to increase muscular power and throwing performance. For beginner and intermediate-trained throwers, resistance training causes a significant increase in shot put performance [7].

Although, shot put is a dynamic event demanding high power production, one of the parameters that determines the power production of a muscle group (whole-body), is muscular strength. However, the relationship between strength and shot put performance has not been thoroughly examined [8]. In light of this information, we think that the shot put technique and its related factors should be examined in more detail. The aim of this research is to evaluate the effects of plyometric training on the shot put technique. It was oriented to improve the basics for the development of power related-indicators such as power (explosive force), acceleration speed, and strength endurance.

### Material and Methods

#### Participants

The study sample included 220 male students, aged 16 years  $\pm$  6 months from Fehmi Lladrovci High School, Glogoc municipality, Republic of Kosovo from the 2019/2020 academic year. The experimental group (110 male students) applied a 12-week program (see the training program paragraph). The control group (110 male students) continued only with their regular physical education lessons (2 times a week).

The study was conducted in a manner that respected the principles established by the Declaration of Helsinki and it was approved by the Ethics Committee of the University.

In the study, data collection tools were as follows. Countermovement jump (CMJ), Standing broad jump (SBJ), Tipple standing jump (TSJ), Standing medicine ball throw (SMBTH), 10 Meters run (10mRUN), 20 Meters run (20mRUN), Plate tapping (PLT), Foot-tapping against the wall (FTAW), Sit-ups in 30 sec (SUP30s), Push-ups in 30 sec (PU30s), Dips (D), Flamingo balance test (FB), and Performance levels of the shot-put technique.

#### Testing Procedures

Subjects were assessed before and after 12 weeks of the plyometric training program, all measurements were taken before the start of the training and after the

end of the training. The tests were preceded by a general warm-up. Countermovement Jump (CMJ) was performed on a contact mat platform [9]. Standing Broad Jump (SBJ) and Standing Triple Jump (STJ) measurements were conducted according to the Nešić Protocol [10]. Standing medicine ball throw (SMBTH) is a test for assessment of explosiveness of the shoulder area (the results were obtained with an accuracy of 1 cm) [10]. 10-meter and 20-meter sprint test measurements were performed according to the Bjelica and Fratrić protocols (the result is given with an accuracy of 0.1 sec) [11]. Plate tapping (PLT) and foot-tapping against the wall (FTW) were used to measure movement speed individually and measured according to the standard procedure used in the euro-fit test battery [12]. The sit-ups in 30 sec (SUP30s) test measured by bending the elbows from the straight position, then approaching the ground and straightening the elbows again; correctly done and completed sit-ups were counted and recorded [13]. Push-ups in 30 sec (PU30s) have validity and reliability [14] to measure the muscular strength endurance of the chest and back arm muscles [14, 15]. General body balance was used by the Flamingo Balance (FLB). A metal beam 50 cm long, 4 cm high, and 3 cm wide were used in this test. During this test, the subject tries to maintain his posture like a flamingo for a long time by standing on the metal beam. For 1 minute, any intervention (that does not fall) made to maintain balance in the beam is considered as a point. The dips (D) test was performed in parallel for men placed in the gym. The subject is placed with support in the hands at the beginning of the parallel bars, with straight legs hanging down. The task of the test holder is from the position described above, as much as possible to perform parallel lifts. The maximum number of parallel rises is estimated. At the moment of ascent, the arms must be completely straight, respectively gathered during the phase of falling on the support. At the same time, the legs are straight. [16].

#### Training Program

The plyometric training program was prepared according to the National Strength and Conditioning Association (NSCA). The volume of the training varied between 85-120 contacts per session, intensity varied between low to high load and was applied 3-4 times per week (fig. 1). Bounding drills normally covered distances greater than 98 feet (30 m) or work time approximately

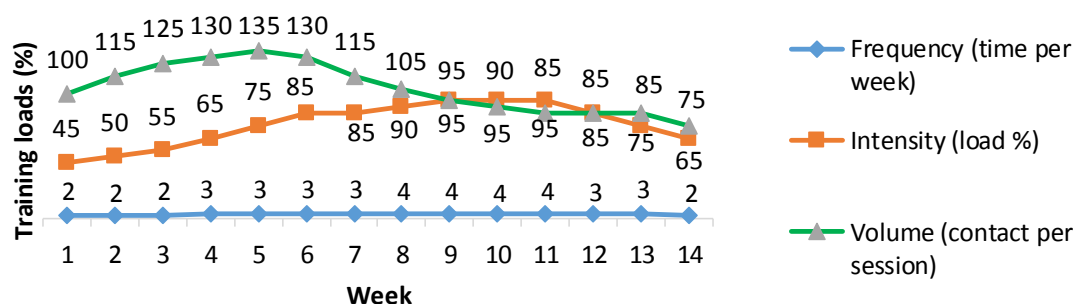


Figure 1. Plyometric training program loads

20-25 sec, and box jumps were repeated 10-15 times. Recovery for depth jumps consisted of 5 to 10 seconds of rest between repetitions and 2 to 3 minutes between sets. The time between sets was determined by a proper work-to-rest ratio (i.e., 1:5 to 1:10) and was specific to the volume and type of drill being performed (tabl. 1).

For safety considerations, athletes who were more than 100 kg were not requested to lift 1 RM squat minimum of 1.5 times his or her body weight, and to stand on one leg for 30 seconds without falling, and were not included in the plyometric training (tabl. 1).

When the training intensity in the lower extremities was low, moderate and low-severity exercises were applied in the trunk and upper body (fig. 2). The same rule applied when working with other parts of the body.

*Statistical Analysis.*

IBM SPSS Statistics 24 software was used for data analysis. To determine the differences between pre and post-test values of the control and experimental groups, ANOVA calculations were made. The development percentage in time (between pre-test and post-test) were calculated by using the formula “%Δ = (x post-test – x pre-

test) / pre-test \*100” where the confidence interval was chosen as 95% and values below p <0.05 were considered statistically significant.

**Results**

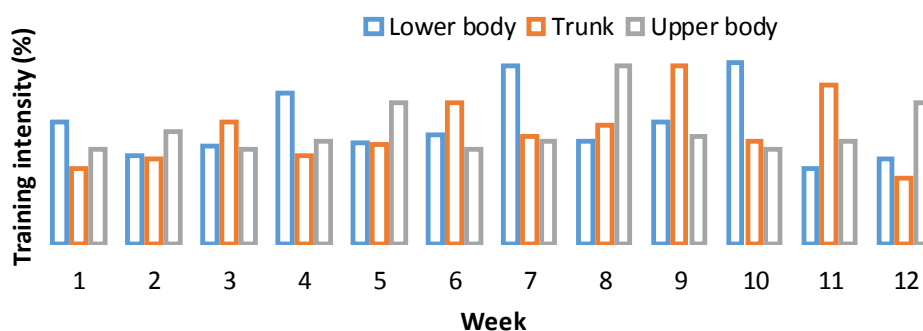
According to the results of Table 2, it was observed that pre- and post-test averages (tests within subjects) of the shot put technique (p<0.05) tests values were statistically different according to measurement in time (interaction; p<0.05). Similar results were observed in the tests between subjects (p<0.05). When analyzing the differences between the groups, it was observed that the shot put technique (Δ%: 50.88) test of the experimental group (plyo-training) had higher development percentages compared to the shot put technique (%Δ: 1.69) tests of the control group (p=.00).

According to the results of Table 3, it was observed that pre- and post-test averages (tests within subjects) of the countermovement jump (p<0.05), standing broad jump (p<0.05), triple standing jump (p<0.05) and standing medicine ball throw (p<0.05) test values were statistically different according to measurement over time

**Table 1.** Exercises included on the plyometric training program

Exercises		
Lower body exercises	Upper body exercises	Trunk exercises
Jump in place	Throws (power drop)	Medicine ball throw
Standing jumps	Plyometric push-ups	45° sit-up
Multi hops and jumps (lateral barrier hop)	Plyometric push-ups	V – sit ups (one rapid repetition)
Bounds (leaping movement upward)	Bench Press with Medicine Ball	Frog sit ups (one rapid repetition)
Bounds (power skip)	Depth Push-Ups (from Box)	Sit-up with medicine ball
Box drills	Alternating Med Ball Plyometric Push Up	Med ball thow (sitt position)
Depth jumps	Push-ups (gymnasti parallels)	
Single-leg vertical jump	Theraband internal rotation (start position).	
	Theraband internal rotation (finish position).	
	Theraband external rotation (finish position).	

**Note:** Depth jumps exercises were not applied between first to sixth week and in the last week.



**Figure 2.** Weekly training intensity

(interaction: CMJ, SBJ, TSJ, SMBTH;  $p < 0.05$ ). Similar results were observed in the tests between subjects (CMJ, SBJ, SMBTH;  $p < 0.05$ , TSJ;  $p > 0.05$ ). When analyzing the differences between the groups it was observed that the countermovement jump ( $\Delta\%$ : 28.90), standing broad jump ( $\Delta\%$ : 26.19), triple standing jump ( $\Delta\%$ : 11.46) and standing medicine ball throw ( $\Delta\%$ : 16.07) results of the experimental group (plyo-training) had higher development percentages compared to the countermovement jump ( $\Delta\%$ : 0.00), standing broad jump ( $\Delta\%$ : 3.02), triple standing jump ( $\Delta\%$ : 1.22) and standing medicine ball throw ( $\Delta\%$ : 1.38) results of the control group (CMJ:  $p = .00$ , SBJ:  $p = .00$ , TSJ:  $p = .06$ , SMBTH:  $p = .00$ ).

According to the results of Table 4, it was observed that

pre- and post-test averages (tests within subjects) of the 10 meters run ( $p < 0.05$ ) and 20 meters run ( $p < 0.05$ ) values were statistically different according to measurement over time (interaction: 10mRUN;  $p < 0.05$ , 20mRUN;  $p < 0.05$ ). The results observed in the tests between subjects were not statistically different ( $p > 0.05$ ). When analyzing the differences between the groups, it was observed that the 10 meters run test ( $\Delta\%$ : -12.67) and 20 meters run test ( $\Delta\%$ : -10.90) of the experimental group (plyo-training) had higher development percentages compared to the 10 meters run ( $\Delta\%$ : -3.05) and 20 meters run ( $\Delta\%$ : -2.31) tests of the control group (10mRUN:  $p = .01$ , 20mRUN:  $p = .14$ ).

According to the results of Table 5 it is seen that pre- and post-test averages (tests within subjects) of the

**Table 2.** Impact of plyometric training in the shot put technique performance level

V	Groups	N	Pre-test	Post-test	Total	» F	p	%Δ	η <sup>2</sup>
			$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$				
SHP	Plio-training	110	5.7±1.14	8.6±1.33	7.2±1.5	55.19	.00*	50.88	
	Control Group	110	5.9±1.26	6.0±1.22	5.95±0.05				
	Total	220	5.8±1.20	7.3±1.81	6.55±0.75				
					« F = 844.261; p = .00*				

NOTE: V – variable; \* $p < 0.05$ . SHP: Shot put technique.  $\bar{X} \pm SD$ : Mean and standard deviation. »: Tests of between-subjects' effects. »: Testing effects within subjects (Greenhouse-Geisser). «: Interaction (Time\*Groups). Δ%: development %. η<sup>2</sup>: partial eta squared, V: Variables

**Table 3.** Impact of plyometric training with respect to power ability (explosive force) factors

V	Groups	N	Pre-test	Post-test	Total	» F	p	%Δ	η <sup>2</sup>
			$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$				
CMJ	Plio-training	110	27.79±4.82	35.82±4.28	31.80±4.02	27.770	.00*	28.90	.11
	Control Group	110	28.44±5.27	28.44±4.90	28.44±0.00				
	Total	220	28.12±5.05	32.13±5.89	30.12±2.01				
					« F = 1771.218; p = .00*				
SBJ	Plio-training	110	157.7±22.16	199.0±20.21	178.3±20.65	21.510	.00*	26.19	.09
	Control Group	110	162.0±23.43	166.9±24.65	164.4±02.45				
	Total	220	159.9±22.85	182.9±27.63	171.4±11.50				
					« F = 833.813; p = .00*				
TSJ	Plio-training	110	530.6±55.45	591.4±57.47	561.0±30.40	3.384	.06	11.46	.01
	Control Group	110	543.1±61.22	549.7±63.68	546.4±03.30				
	Total	220	536.9±58.61	570.5±64.02	553.7±16.80				
					« F = 422.013; p = .00*				
SMBTH	Plio-training	110	453.1±61.80	525.9±61.44	489.5±36.40	11.073	.00*	16.07	.04
	Control Group	110	457.6±69.42	463.9±68.85	460.7±03.15				
	Total	220	455.3±65.61	494.8±72.20	475.1±19.75				
					« F = 400.012; p = .00*				

NOTE: V – variable; \* $p < 0.05$ . CMJ: Countermovement jump, SBJ: Standing broad jump, TSJ: Triple standing jump, SMBTH: Standing medicine ball throw.  $\bar{X} \pm SD$ : Mean and standard deviation. »: Tests of between-subjects' effects. »: Tests of within subjects' effects (Greenhouse-Geisser). «: Interaction (Time\*Groups). Δ%: development %. η<sup>2</sup>: partial eta squared.

plate tapping ( $p < 0.05$ ), foot-tapping against the wall ( $p < 0.05$ ), sit ups in 30 sec ( $p < 0.05$ ) and push-ups in 30 sec ( $p < 0.05$ ) test values were statistically different according to measurement over time (interaction: PLT, FTAW, SUP30s, SMBTH;  $p < 0.05$ ). Similar results were observed in the SUP30s ( $p < 0.05$ ) and PU30s ( $p < 0.05$ ) between subjects. However, the results showed that in the PLT and FTAW results between subjects did not have any statistical difference ( $p > 0.05$ ). When analyzing the differences between the groups, it was observed that the plate tapping ( $\Delta\%$ : -12.43), foot-tapping against the wall ( $\Delta\%$ : -9.32), sit ups in 30 sec ( $\Delta\%$ : 40.00) and push-ups in 30 sec ( $\Delta\%$ : 45.83) test of the experimental group (plyo-training) had higher development percentages compared to the plate tapping ( $\Delta\%$ : -2.18), foot-tapping against the wall ( $\Delta\%$ : -2.25), sit ups in 30 sec ( $\Delta\%$ : 2.01) and push-

ups in 30 sec ( $\Delta\%$ : 2.87) tests of the control group (PLT:  $p = .23$ , FTAW:  $p = .45$ , SUP30s:  $p = .00$ , PU30s:  $p = .00$ ).

According to the results of Table 6, it was observed that pre- and post-test averages values (tests within subjects) of the dips ( $p < 0.05$ ) and flamingo balance ( $p < 0.05$ ) were statistically different according to measurement over time (interaction: D, FB:  $p = .00$ ). Similar results were observed in the D test between subjects ( $p < 0.05$ ). However, the results indicated that there was no statistical difference ( $p > 0.05$ ) in the FB test between the subjects.

When analyzing the differences between the groups, it was observed that the dips ( $\Delta\%$ : 70.51) and flamingo balance ( $\Delta\%$ : -50.00) test of the experimental group (plyo-training) had higher development percentages compared to the dips ( $\Delta\%$ : 5.95) and flamingo balance ( $\Delta\%$ : -15.38) tests of the control group (D:  $p = .01$ , FB:  $p = .45$ ).

**Table 4.** Impact of plyometric training in acceleration ability factors

V	Groups	N	Pre-test	Post-test	Total	» F	p	%Δ	η <sup>2</sup>
			$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$				
10mRUN	Plio-training	110	2.408±.35	2.103±.23	2.256±0.15	6.481	.01*	-12.67	.02
	Control Group	110	2.390±.33	2.317±.30	2.354±0.04				
	Total	220	2.399±.34	2.210±.29	2.305±0.09				
					« F=52.581; p=.00*				
20mRUN	Plio-training	110	3.974±.53	3.541±.35	3.758±0.22	2.136	.14	-10.90	.01
	Control Group	110	3.888±.48	3.798±.45	3.843±0.04				
	Total	220	3.931±.50	3.670±.42	3.800±0.13				
					« F=69.509; p=.00*				

NOTE: V – variable; \* $p < 0.05$ . 10mRUN: 10 Meters run, 20mRUN: 20 Meters run.  $\bar{X} \pm SD$ : Mean and standard deviation. »: Tests of between-subjects' effects. »: Tests of within subjects' effects (Greenhouse-Geisser). «: Interaction (Time\*Groups). Δ%: development %. η<sup>2</sup>: partial eta squared

**Table 5.** Impact of plyometric training in the speed of the upper and lower extremities and endurance in force factors

V	Groups	N	Pre-test	Post-test	Total	» F	p	%Δ	η <sup>2</sup>
			$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$				
PLT	Plio-training	110	10.86±1.66	09.51±1.32	10.18±0.68	1.404	.23	-12.43	.00
	Control Group	110	10.55±1.65	10.32±1.63	10.43±0.12				
	Total	220	10.71±.166	09.82±1.53	10.31±0.45				
					« F=126.764; p=.00*				
FTAW	Plio-training	110	14.05±2.18	12.74±2.11	13.39±0.66	.572	.45	-9.32	.00
	Control Group	110	13.77±2.31	13.46±2.17	13.61±0.15				
	Total	220	13.91±2.25	13.10±2.16	13.50±0.41				
					« F=41.907; p=.00*				
SUP30s	Plio-training	110	19.0±3.78	26.6±3.85	22.8±3.80	26.932	.00*	40.00	.11
	Control Group	110	19.9±4.24	20.3±4.17	20.1±0.20				
	Total	220	19.5±4.03	23.4±5.09	21.4±1.95				
					« F=619.485; p=.00*				
PU30s	Plio-training	110	16.8±7.38	24.5±7.36	20.6±3.85	8.783	.00*	45.83	.03
	Control Group	110	17.4±7.97	17.9±8.02	17.6±0.25				
	Total	220	17.1±7.67	21.3±8.36	19.1±2.10				
					« F=387.229; p=.00*				

NOTE: V – variable; \* $p < 0.05$ . PLT: Plate tapping, (FTAW): Foot-tapping against the wall, SUP30s: Sit-ups in 30 secs, PU30s: Push-ups in 30 sec.  $\bar{X} \pm SD$ : Mean and standard deviation. »: Tests of between-subjects' effects. »: Tests of within subjects' effects (Greenhouse-Geisser). «: Interaction (Time\*Groups). Δ%: development %. η<sup>2</sup>: partial eta squared.



**Table 6.** Impact of plyometric training of the speed of the upper and lower extremities and endurance in force factors

V	Groups	N	Pre-test	Post-test	Total	» F	p	%Δ	η <sup>2</sup>
			$\bar{X} \pm SD$	$\bar{X} \pm SD$	$\bar{X} \pm SD$				
D	Plio-training	110	7.8±5.16	13.3±5.69	10.6±2.8	6.60	.01	70.51	
	Control Group	110	8.4±5.79	8.9±5.52	8.65±0.25				
	Total	220	8.1±5.47	11.1±6.00	9.6±1.5				
						» F = 489.327; p = .00*			
						« F = 322.731; p = .00*			
FB	Plio-training	110	8.8±6.96	4.4±4.44	6.6±2.2	.57	.45	-50.00	
	Control Group	110	7.8±6.98	6.6±5.97	7.2±0.6				
	Total	220	8.3±6.97	5.5±5.37	6.9±1.4				
						» F = 84.899; p = .00*			
						« F = 28.660; p = .00*			

NOTE: V – variable; \*p<0.05. PLT: D: Dips, FB: Flamingo balance test.  $\bar{X} \pm SD$ : Mean and standard deviation. »: Tests of between-subjects' effects. »: Tests of within subjects' effects (Greenhouse-Geisser). «: Interaction (Time\*Groups). Δ%: development %. η<sup>2</sup>: partial eta squared.

### Discussion

In the study it was observed that pre- and post-test averages (within and between subjects) of the shot put technique (p<0.05) were statistically different according to measurement over time (interaction; p<0.05). When analyzing the development percentage, it was observed that the performance of shot put technique (Δ%: 50.8) of the experimental group compared to the shot put technique (Δ%: 1.6) results of the control group had developed by 49.2%.

If we refer to the research of Mustapha et al. [17], they also found significant statistical differences in the pre-test and post-test in the experimental sample for muscular strength and digital achievement in the shot put technique. According to the researchers, this result was due to the proposed training program based on scientific foundations of the application of physical exercises of quality that are related to the game, especially the use of the plyometric exercises (08 weeks & 02 times in one week). Furthermore, T-test values for the experimental sample was also (2.57 and 3.04) larger than the tabulated T-test, which means there was also the existence of a significant difference between the pre-test and post-test calculated average in favor of the post-test group [17].

Similar results in the shot put technique were also observed in analyzing the impact of the plyometric training program in the motor abilities related to the shot put technique. Applied plyometric training program benefits were not just in the shot put technique, but also improved all motor abilities related to the technique such as a power, strength endurance, speed, and acceleration. Thus, the development of the shot put technique occurred by the increase in motor abilities related to the shot put technique as a result of the plyometric training program.

Referring to the literature, ten weeks of strength and power training induced significant increases in the shot put throw, standing long jump work production, and sprinting performance. These changes were accompanied by adaptations in muscle thickness and fascicle length. The current data suggest that examination of muscle thickness and performance in explosive field tests may partly predict the training-induced increase in actual track

and field throwing performance [18].

When the same analyses were applied in the explosive force factors, it was observed that the differences within subjects and between subjects of the countermovement jump (p<0.05), standing broad jump (p<0.05), triple standing jump (p<0.05) and standing medicine ball throw (p<0.05) test values were statistically different (p<0.05). When analyzing the development percentage, it was observed that the countermovement jump (Δ%: 28.9), standing broad jump (Δ%: 26.1), triple standing jump (Δ%: 11.4) and standing medicine ball throw (Δ%: 16.0) test results of the experimental group (plyo-training); compared to the countermovement jump (Δ%: 0.00), standing broad jump (Δ%: 3.0), triple standing jump (Δ%: 1.2) and standing medicine ball throw (Δ%: 1.3), have shown higher development percentages (CMJ: 28.9%, SBJ: 23.1%, TSJ: 10.2%, SMBTH: 14.7%).

Based on the literature, we can see that there were statistically significant differences in post-test between the control and experimental sample in favor of the experimental group. This indicates that plyometric exercises were more effective in improving performance in the shot put through the use of medicine balls and iron balls with different weights. This actually confirms the effectiveness of using plyometric exercises leads to an improvement in physical abilities and performance in sports activities [19, 20]. If we see the literature, we can verify that a combined plyometric and squat training program significantly increased vertical jump results compared to training with squats or plyometric alone [21].

With regards to acceleration abilities, it was observed that within subjects the 10 meters run (p<0.05) and 20 meters run (p<0.05) test values were statistically different according to measurement over time. The results observed in the tests between subjects were not statistically different (p>0.05).

When analyzing the development percentage, it was observed that the 10 meters run test (Δ%: -12.6) and 20 meters run (Δ%: -10.9) test of the experimental group (plyo-training) have shown higher development percentages compared to the 10 meters run (Δ%: -3.0) and 20 meters run (Δ%: -2.3) tests of the control group (10m

run: 9%, 20m run: 8.6%).

The literature showed that after a plyometric training program of 10 weeks duration found that the jump program increased the velocity for running distances of 0-30, 10-20, and 20-30 [22]. Results of several investigations involving adults suggest that combining plyometric training with other training programs may be useful for enhancing muscular performance and running velocity [21, 23, 24].

Analysis of speed, strength endurance and balance, showed that within subjects and between subjects of the plate tapping ( $p < 0.05$ ), foot-tapping against the wall ( $p < 0.05$ ), sit ups in 30 sec ( $p < 0.05$ ) and push-ups in 30 sec ( $p < 0.05$ ) tests, were impacted by plyometric training applied on the study sample ( $p < 0.05$ ).

When analyzing the development percentages, it was observed that plate tapping ( $\Delta\%$ : -12.4), foot-tapping against the wall ( $\Delta\%$ : -9.3), sit ups in 30 sec ( $\Delta\%$ : 40.0) and push-ups in 30 sec ( $\Delta\%$ : 45.8) tests of the experimental group (plyo-training) showed higher development percentages compared to the plate tapping ( $\Delta\%$ : -2.1), foot-tapping against the wall ( $\Delta\%$ : -2.2), sit ups in 30 secs ( $\Delta\%$ : 2.0) and push-ups in 30 sec ( $\Delta\%$ : 2.8) tests of the control group (PLT: 10.3%, FTAW: 7.1%, SUP30s: 38.0%, PU30s: 43.0%).

Kontou et al. (2018) in their study confirms that after isometric push-ups, participants have a higher percentage increase in shot-put performance [25]. Moreover, within subjects and between subjects regarding the dips and flamingo balance tests, values were statistically different ( $p < 0.05$ ). When analyzing the development percentage,

it was observed that the dips ( $\Delta\%$ : 70.5) and flamingo balance ( $\Delta\%$ : -50.0) test of the experimental group (plyo-training) had higher development percentages compared to the dips ( $\Delta\%$ : 5.9) and flamingo balance ( $\Delta\%$ : -15.3) tests of the control group (D: 64.6%, FB: 34.7%).

The research showed that when the effects of psychomotor training on balance was taken into consideration, a statistically significant difference was found between pre-test ( $\bar{x}$  4.59) and post-test ( $\bar{x}$  1.98) in the training group (experimental group) ( $p < 0.01$ ). No statistically significant difference was found between the balance pre-test ( $\bar{x}$  4.54) and post-test ( $\bar{x}$  3.69) in the non-training group (control group) ( $p < 0.05$ ) [26].

### Conclusion

In conclusion, the impact of the plyometric training program on motor abilities related to the shot put technique also observed similar results as the training program's impact on the shot put technique. The applied plyometric training program benefits were not just in the shot put technique but also improved all motor abilities related to the shot put technique such as power, strength endurance, speed and acceleration. Therefore, the development of the shot put technique occurred by an increase in motor abilities related to the shot put technique as a result of the plyometric training program.

### Conflict of interests

No potential conflict of interest was reported by the authors.

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