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The effect of plyometric training on the anthropometric characteristics of the high school male students

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Abstract

Objective: to compare the effect of a 12-week plyometric training on the anthropometric parameters high, weight, body mass index (BMI), breadth, circumferences and skinfold of high school students. **Methods**: the study was conducted on a sample of 220 male volunteer students, that was divided in experimental (n=110) and control (n=110) groups, who were students of *Fehmi Lladroci high school* from Glogoc, Republic of Kosovo. The age of the students ranged from 15-16 years. The anthropometric variables were measured using standardized equipment before and after a twelve-week training period. The students of the experimental group were trained for three days per week (monday, wednesday, friday). The analysis of the data was done with the IBM SPSS Statistics 22 software. The statistics obtained were provided by analysis of repeated measure ANOVA. The development percentage in time were calculated with formula "%Δ = (x post-test – x pre-test) / pre-test *100". **Results**: according to the results, we observed that the plyometric training program applied in 12 weeks increased anthropometric parameters (H: %Δ:0.52, W: %Δ:2.06 and BMI: %Δ:1.24; ABB: %Δ:2.54; ARAG: %Δ:3.09; ACHG:%Δ:1.05, ATHG:%Δ:0.85 and ACG:%Δ:3.53; ATS: %Δ:-10.99, AAS: %Δ:-10.66, ASS: %Δ:-11.69 and AMCS:%Δ:-13.88). **Conclusion**: it was showed a significant improvement in anthropometry to the experimental group as indicated by the significant value which was greater than the control group after the plyometric exercises applied to children aged 16 years-old.

Keywords: plyometric training, anthropometry, body composition.

Introduction

Physical training is one of the most important factors for each sport, because physical training increases the efficiency and the effectiveness of the athletes. Athletes perform a variety of explosive actions in plyometric training, which helps to improve their skills. A lot of studies have shown that plyometric exercise can be beneficial to a teenagers' overall health while promoting a positive body image.

An important implication on sports where players perform numerous explosive movements, and physical activity, such as kicking, jumping, turning, sprinting, and changing directions during the sports activity (Chaouachi et al., 2009; Stølen et al., 2005). A lot of scientific research have confirmed that plyometric training can enhance muscle strength, power (Michailidis et al., 2013) and agility (Arazi et al., 2012; Ramirez et al., 2014).

Anthropometry has a great tradition and importance in sports. The anthropometric data on the general population are very important to determine the physical dimensions of the workspace, various equipment and clothing that suit the user as well as to avoid a physical discrepancy between the dimensions of products and equipment and corresponding dimensions of different user (Bridger, 1995). Body composition plays a key role in monitoring performance and training in all athletes, because body composition may influence athletes' performance (Thomas et al., 2016). In most sports branches the anthropometric characteristics are one of the most important factors to indicate whether an athlete can be competitive in the highest level in that sport (Bourgois et al., 2002). Anthropometric data should be collected regularly and provided as a standard reference for preliminary health monitoring, based on the World Health Organization (WHO).

Physical activity helps people to adapt their living, environmental conditions and plays an important role in daily activities. Physical activity is closely related to the state of human health and has a very good effect on quality of life, efficiency of learning and work, as well as the contribution of physical activity. Physical activity consists of performance-related physical ability and health-related physical ability (Fang, 1997). Genetics also somehow determines physical ability (Esmaeilzadeh et al., 2013), but environmental factors including the level of physical activity (Gutin et al., 2005; Ruiz et al., 2006), socio-economic status (Jiménez et al. 2010) standing in front of the television and also anthropometric factors (Mota et al., 2006) greatly modify it. Far as fitness levels decrease with age (Bouchard & Shepard, 1994) engaging in physical activity should be highly suggested.

Training is an important part of physical activity which improves physical performance to the athletes. Also, muscle strength and power are important determinants of a successful performance in a lot of sports (Kaur & Bhardwaj, 2018).

To the adolescents, the relation between body composition and physical fitness has been well established. Overall, adolescents with normal weight present better physical fitness than underweight and overweight (Esmaeilzadeh & Ebadollahzadeh, 2012). In this context, the aim of the study is to determine the effect of plyometric training on the anthropometrical characteristics of male student aged 15-16 years old. So, based on this goal, this study aims to determine the effect of plyometric training on the anthropometrical characteristics of high school male student living in Kosovo.

Material and methods

Determining the effect of plyometric training on anthropometric characteristic was used as an experimental approach to the research.

Participants

The study sample included 220 male high school students, who are students of *Fehmi Lladrovci high school* from Glogoc, Republic of Kosovo. The selected male students were further divided in experimental (EG) and control (CG) groups, with 110 in each. The random method of group dividing was applied. Experimental group applied a 12-week plyometric training program with one hour per day, three times a week, whereas the control group, continued only with their regular physical education lessons (2 times a week). Subjects were assessed before and after the twelve weeks of the plyometric exercise program. All measurements were taken one week before and after training at the same time of day. Tests followed a general warm-up that consisted of running, minimize drills and stretching. 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 (IRB protocol number 877/24).

Anthropometric characteristics and measurement protocols

Anthropometric variables were measured using standardized equipments. Anthropometric measurements included height, weight, body mass index (BMI), Biacromial breadth, Biiliocristal breadth, Relaxed arm girth, Chest girth, Thigh girth, Calf girth, Triceps skinfold, Abdominal skinfold, Subscapular skinfold, Medial calf skinfold (Preedy, 2012).

Body height was measured by the *Martin anthropometer* and the data was read with an accuracy of 0.1 cm. The body weight and body mass index were measured with medical scales (Tanita BC 545 N Innerscan Segmental Personal Body Analysis) and the data was read with an accuracy of 0.1 kg. Skin fold thickness were measured with a skinfold caliper. Anthropometric tape was used for measuring girth, while sliding caliper was used to measure bone diameter (Lohmann et al., 1988).

Training program

The plyometric training program was prepared according to the National Strength and Conditioning Association (NSCA) and applied 3 time per week. Plyometric Training would be carried out on Monday, Wednesday, Friday for twelve weeks. The load for the training program will be progressively increased from the beginning to the end of the training session. Scope: a large number of jumps will be performed at the end of the 12-week training program, the volume of the training varying between 180 and 240 jumps within a week. Bounding drills normally covered distances greater than 98 feet (30 m) or work time approximately 20-25 secs, box jumps 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 is specific to the volume and type of drill being performed (Potach & Chu, 2016; Sole, 2018).

Training is applied in order to provide high intensity training for each body part (trunk, upper body, lower body) at least once a week. When the training severity in the lower extremities was low, moderate and low-severity exercises were applied in trunk and upper body. The same rule applied when working with the other parts of the body. Also, plyometric training of each body part follows the intensity and volume of the past week and is connected to the next week training.

Table 1. Plyometric program applied with the experimental group

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 (lateralbarrier hop)	Plyometric push-ups Bench Press with Medicine Ball	V – sit ups (one rapid repetition)
Bounds (leaping movementupward)	Depth Push-Ups (from Box)	Frog sit ups (one rapid repetition)
Bounds (power skip)	Alternating Med Ball Plyometric Push Up	Sit-up with medicine ball
Box drills	Push-ups (gymnastic parallels)	Med ball throw (sitting position)
Depth jumps		
Single-leg vertical jump		

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

Data Analysis

To process the results of the study, IBM SPSS Statistics 24 software was used. The statistics obtained were provided by two-way repeated analysis of variance (repeated measure ANOVA). The development percentage in time were calculated by using the formula "%Δ = (x post-test – x pre-test) / pre-test *100" and confidence interval was chosen as 95% and values below p <0.05 were considered statistically significant.

Results

Table 2. Descriptive statistics of the sample.

	Age	N	Minimum	Maximum	Mean/SD
Hight		220	151,0	195,0	173,995 ± 6,9135
Weight	16	220	38,10	113,00	63,0886 ± 11,84759
BMI		220	13,90	37,70	20,7950 ± 3,69753

Table 2 carries out the descriptive statistics such as age, mean, min, and max of the analyzed variables in the study. Thus, the results of the study may be representative of this group of students, and eventually may be beneficial in order to predict the results for the same variables in different age groups and categories of students.

Table 3. Effect of plyometric training exercise on body height, body weight and BMI.

	Groups	N	Pre-test	Post-test	Total	»		%Δ	η2
			X̄±SD	X̄±SD	X̄±SD	F	p		
HEIGHT	Plio-training	110	174.0±6.23	175.1±6.24	174.5±0.30	.033	.85	0.63	.00
	Control Group	110	173.9±7.56	174.8±7.51	174.3±0.25			0.52	
	Total	220	173.9±6.91	174.9±6.89	174.8±0.05				
			› F = 333.225; p =.000			‹ F = 4.037; p =.04			
WEIGHT	Plio-training	110	62.9±11.67	64.0±10.91	63.4±0.55	.028	.00*	1.75	.00
	Control Group	110	63.1±12.07	64.4±11.95	63.4±0.65			2.06	
	Total	220	63.0±11.84	64.2±11.42	63.6±0.60				
			› F= 50.519; p=.000			‹ F .218 ; p= .641			
BMI	Plio-training	110	20.63±3.60	20.97±3.20	20.80±0.17	.347	.55	1.65	.00
	Control Group	110	20.95±3.79	21.21±3.64	21.08±0.13			1.24	
	Total	220	20.79±3.69	21.09±3.42	20.94±0.15				
			› F= 12.986; p= .000*			‹ F .171; p= .679			

*p<0.05. H: Height, W: Weight, BMI: Body mass index. X̄±SD: Mean and standard deviation. **»**: Tests of between-subjects' effects. **›**: Tests of Within subjects' effects (Greenhouse-Geisser). **‹**: Interaction (Time*Groups). %Δ: development %. η2: partial eta squared.

According to the results of table 3, it was observed that pre-test and post-test averages of the Height (F = 333.225; p =.000), Weight (F= 50.519; p=.000) and BMI (F= 12.986; p= .000), test values were statistically different according to measurement over time (H: F = 4.037; p =.04, W: F .218; p=.641; BMI: F .171; p= .679).

When analyzing the differences between the groups, it was observed that the Height (%Δ:0.63), Weight (%Δ:1.75), and BMI (%Δ:1.65) test of the experimental group (plio-training) had small development percentages compared to the Height (%Δ:0.52), Weight (%Δ:2.06) and BMI (%Δ:1.24) tests of the control group (H: p = 0,85; W: p = .00; BMI: p = .55).

Table 4. Effect of plyometric training exercise on body breadth.

	Groups	N	Pre-test	Post-test	Total	»		%Δ
			X̄±SD	X̄±SD	X̄±SD	F	p	
ABB	Plio-training	110	39.3±2.20	40.3±2.28	39.8±0.5	.129	.719	2.54
	Control Group	110	39.6±2.38	40.2±2.34	39.9±0.3			1.52
	Total	220	39.5±2.29	40.2±2.30	39.8±0.3			
			› F = 207.257; p =.00			‹ F =11.348; p =.00		
ABIB	Plio-training	110	31.1±2.05	31.1±1.85	31.1±0.0	2.19	.14	0.00
	Control Group	110	31.4±2.16	31.6±2.11	31.5±0.1			0.64
	Total	220	31.2±2.11	31.3±1.99	31.25±0.05			
			› F =3.899; p =.05			‹ F =1.501; p =.22		

*p<0.05. ABB - Biacromial breadth, ABIB - Biiliocristal breadth. X̄±SD: Mean and standard deviation. »: Tests of between-subjects' effects. ›: Tests of Within subjects' effects (Greenhouse-Geisser). ‹: Interaction (Time*Groups). %Δ: development %. η2: partial eta squared.

Based to the results of table 4, it was observed that pre-test and post-test averages of the: ABB - Biacromial breadth (F = 207.257; p =.00), ABIB- Biiliocristal breadth (F =3.899; p =.05), test values, statistically, do not change at all based on measurement time. The exception is the variable ABB - Biacromial breadth, which has little development (ABB: F =11.348; p =.00; ABIB: F =1.501; p =.22).

When analyzing the differences between the groups, it was observed that the Biacromial breadth (%Δ:2.54) and Biiliocristal breadth (%Δ:0.00), test of the experimental group (plio-training), only variable ABB had a small percentage of development compare to the control group (ABB: p = .719; ABIB: p = .14).

Table 5. Effect of plyometric training exercise on body circumference.

	Groups	N	Pre-test	Post-test	Total	»		%Δ
			X̄±SD	X̄±SD	X̄±SD	F	p	
ARAG	Plio-training	110	25.9±3.40	26.7±3.28	26.3±0.4	2.17	.14	3.09
	Control Group	110	25.7±3.08	25.7±2.99	25.7±0			0.00
	Total	220	25.8±3.24	26.2±3.17	26±0.2			
			› F =128.257; p =.00			‹ F =87.342; p =.00		
ACHG	Plio-training	110	86.0±7.42	86.9±7.33	86.5±0.5	.67	.41	1.05
	Control Group	110	85.6±7.40	85.7±7.39	85.6±0.05			0.12
	Total	220	85.8±7.40	86.3±7.37	86.0±0.25			
			› F =92.230; p =.00			‹ F =61.045; p =.00		
ATHG	Plio-training	110	47.2±5.79	47.6±5.61	47.4±0.2	1.82	.17	0.85
	Control Group	110	46.4±5.22	46.4±5.11	46.4±0			0.00
	Total	220	46.8±5.52	47.0±5.39	46.9±0.1			
			› F =10.741; p =.00			‹ F =12.009; p =.00		
ACG	Plio-training	110	34.0±3.13	35.2±2.92	34.6±0.6	2.27	.01	3.53
	Control Group	110	33.9±3.24	34.0±3.25	33.95±0.05			0.29
	Total	220	33.9±3.18	34.6±3.14	34.25±0.35			
			› F =130.830; p =.00			‹ F =83.788; p =.00		

*p<0.05. ARAG - Relaxed arm girth, ACHG - Chest girth, ATHG - Thigh girth, ACG - Calf girth. X̄±SD: Mean and standard deviation. »: Tests of between-subjects' effects. ›: Tests of Within subjects' effects (Greenhouse-Geisser). ‹: Interaction (Time*Groups). %Δ: development %. η2: partial eta squared.

Based on the table 5, it was observed that pre-test and post-test averages of the: ARAG - Relaxed arm girth (F =128.257; p =.00), ACHG - Chest girth (F =92.230; p =.00), ATHG - Thigh girth (F =10.741; p =.00) and ACG - Calf girth (F =130.830; p =.00) test values statistically vary based on measurement time (ARAG: F =87.342; p =.00; ACHG: F =61.045; p =.00; ATHG: F =12.009; p =.00; ACG: F =83.788; p =.00).

When analyzing the differences between the groups, it was observed that the: Relaxed arm girth (%Δ:3.09), Chest girth (%Δ:1.05), Thigh girth (%Δ:0.85) and Calf girth (%Δ:3.53) test of the experimental group (plio-training), has a noticeable percentage of development, compared to Relaxed arm girth (%Δ:0.00), Chest girth (%Δ:0.12), Thigh girth (%Δ:0.00) and Calf girth (%Δ:0.29) to the control group (ARAG: p = .14; ACHG: p = .41; ATHG: p = .17; ACG: p = .01).

Table 6. Effect of plyometric training exercise on body skinfold thickness.

	Groups	N	Pre-test	Post-test	Total	»		%Δ
			X̄±SD	X̄±SD	X̄±SD	F	p	
ATS	Plio-training	110	9.1±4.45	8.1±3.8	8.6±0.5	.06	.79	-10.99
	Control Group	110	8.8±3.98	8.7±4.00	8.75±0.05			-1.14
	Total	220	9.0±4.21	8.4±3.90	8.7±0.3			
			› F =92.735; p =.00			‹ F =75.253; p =.00		
AAS	Plio-training	110	12.2±7.70	10.9±7.05	11.6±0.6	.45	.49	-10.66
	Control Group	110	11.7±7.16	12.6±7.20	12.15±0.45			7.69
	Total	220	12.0±7.42	11.8±7.16	11.9±0.1			
			› F =7.844; p =.00			‹ F =241.207; p =.00		
ASS	Plio-training	110	7.7±3.53	6.8±2.95	7.3±0.5	.47	.49	-11.69
	Control Group	110	7.3±3.38	7.7±3.56	7.5±0.2			5.48
	Total	220	7.5±3.45	7.3±3.29	7.4±0.1			
			› F =7.749; p =.00			‹ F =71.866; p =.00		
AMCS	Plio-training	110	9.4±4.41	8.1±3.80	8.8±0.7	.51	.47	-13.88
	Control Group	110	9.1±3.95	9.2±3.83	9.15±0.05			1.10
	Total	220	9.3±4.18	8.7±3.85	9±0.3			
			› F =99.965; p =.00			‹ F =140.622; p =.00		

*p<0.05. ATS - Triceps skinfold, AAS - Abdominal skinfold, ASS - Subscapular skinfold, AMCS - Medial calf skinfold. X̄±SD: Mean and standard deviation. **»**: Tests of between-subjects' effects. **›**: Tests of Within subjects' effects (Greenhouse-Geisser). **‹**: Interaction (Time*Groups). %Δ: development %. η2: partial eta squared.

According to the results of table 6, it was observed that pre-test and post-test averages of the ATS - Triceps skinfold (F =92.735; p =.00), AAS - Abdominal skinfold (F =7.844; p =.00), ASS - Subscapular skinfold (F =7.749; p =.00) and AMCS - Medial calf skinfold (F =99.965; p =.00), test values statistically vary based on measurement time (ATS: F =75.253; p =.00; AAS: F =241.207; p =.00; ASS: F =71.866; p =.00 and AMCS: F =140.622; p =.00).

When analyzing the differences between the groups, it was observed that the Triceps skinfold (%Δ:-10.99), Abdominal skinfold (%Δ:-10.66), Subscapular skinfold (%Δ:-11.69) and Medial calf skinfold (%Δ:-13.88) in the experimental group (with training program), there are a significant percentage of developmental decline, compared to Triceps skinfold (%Δ:-1.14), Abdominal skinfold (%Δ:7.69), Subscapular skinfold (%Δ:5.48) and Medial calf skinfold (%Δ:1.10), to the control group, a group in which we have an increase in the development of body skinfold thickness (ATS: p = .79; AAS: p = .49; ASS: p = .49; AMCS: p = .47).

Discussion

According to the results of table 3, it was observed that pre-test and post-test averages of the Height, Weight and BMI, test values were statistically different according to measurement over time. When analyzing the differences between the groups, it was observed that the Height (%Δ:0.63), Weight (%Δ:1.75), and BMI (%Δ:1.65) test of the experimental group (plio-training) had small development percentages compared to the Height (%Δ:0.52), Weight (%Δ:2.06) and BMI (%Δ:1.24) tests of the control group. This can be explained by the short duration of the study (12 weeks) and by the fact that our subjects belonged to the population of young men, healthy and physically quite active. In their study, Spurrs et al. (2003), after applying plyometric training did not find any change in body mass and adipose tissue percentage. Whereas, in previous studies has been confirmed that anthropometry and body composition change throughout the course of a soccer season (Mukherjee & Chia, 2010; Hammami et al., 2013; Oyón et al., 2016).

Based to the results of table 4, it was observed that pre-test and post-test averages of the Biacromial breadth, Biiliocristal breadth, test values, statistically do not change at all based on measurement time, when analyzing the differences between the groups it was observed that only variable Biacromial breadth had a small percentage of development, compare to the control group (ABB:2.54%).

Based on the table 5, it was observed that pre-test and post-test averages of the Relaxed arm girth, Chest girth, Thigh girth and Calf girth, test values statistically vary based on measurement time; when analyzing the differences between the groups it was observed that the Relaxed arm girth (%Δ:3.09), Chest girth (%Δ:1.05), Thigh girth (%Δ:0.85) and Calf girth (%Δ:3.53) test of the experimental group (plio-training), has a noticeable percentage of development, compared to Relaxed arm girth (%Δ:0.00), Chest girth (%Δ:0.12), Thigh girth (%Δ:0.00) and Calf girth (%Δ:0.29) to the control group (ARAG:3.09%; ACHG: 1.05%; ATHG: 0.85%; ACG: 3.53%). The study of Qi et al. (2019), indicates that resistance training combined with plyometric training can be safe and effective on reduce muscular girth in boys aged between 8 and 12 years.

According to the results of table 6, it was observed that pre-test and post-test averages of the Triceps skinfold, Abdominal skinfold, Subscapular skinfold and Medial calf skinfold test values statistically vary based on measurement time. When analyzing the differences between the groups, it was observed that the Triceps skinfold (%Δ:-10.99), Abdominal skinfold (%Δ:-10.66), Subscapular skinfold (%Δ:-11.69) and Medial calf skinfold (%Δ:-13.88) in the experimental group (with training program), there is a significant percentage of developmental decline, compared to Triceps skinfold (%Δ:-1.14), Abdominal skinfold (%Δ:7.69), Subscapular skinfold (%Δ:5.48) and Medial calf skinfold (%Δ:1.10) to the control group, a group in which we have an increase in the development of body skinfold thickness (ATS:-10.99%; AAS:-10.66%; ASS:-11.69%; AMCS:-13.88%).

Based on the research of Kaur and Bhardwaj (2018), it was inferred that no significant difference exists of experimental group between pre-test and post-test on anthropometric variables: Height, Upper leg length, Fore leg length, Thigh girth, Knee girth, Calf girth. But the research of Lesinski et al. (2017), revealed a significant main effect of time for almost all anthropometric and body composition measures, except for the BMI. Body height (11%; $d = 3.39$; $p < 0.001$) and total absolute lean body mass (14%; $d = 2.50$; $p < 0.01$) significantly increased over the course of the season (i.e., T1-T6) (Lesinski et al. 2017).

Conclusion

In view of the results of this study, which aimed to verify whether alterations occur in anthropometric variables in high school students who participated in a plyometric program, one can infer that the effect of plyometric training has been increased from pre to post training. The plyometric training brings a positive effect in anthropometric variables on high school male student. These results suggest the importance of evaluating anthropometric variables by body region in group involved in this program.

We suggest that the future studies should examine the effects of long-term (more than 12 weeks) plyometric training on anthropometric characteristics with carefully controlling the dietary status of the subjects.

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