

EFFECT OF 19 WEEKS OF PLYOMETRY COMBINED IN CHILD ATHLETES

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Abstract: In athletics, explosive strength is imperative for most athletics events, and training the lower body is the main concern of athletics specialists.

The aim of this study was to investigate the effectiveness of a combined plyometric intervention program versus a plyometric program made through age-adapted simple jumps.

The present research was carried out in the "Lia Manoliu" Sports Complex, Bucharest, for 21 weeks, out of which the first and last week were intended for the initial and final tests. The research samples were made up of 10 athletes each, of both sexes, aged 12/13 years. All the subjects of the research participated in 3 weekly trainings, with a duration of 90 minutes and had a weekly intervention program of plyometric type; The training of the experimental group was one that combined simple plyometric jumps over obstacles, with and without load, accessible to the age, as well as depth jumps with landing on the ground in flexion of 90°, followed by an active impulse of both legs on ground. The training of the control group consisted of various simple plyometric jumps.

Analyzing the results of the experiment, we can conclude that the combined plyometric training revealed a superior improvement in the lactic acid anaerobic power of the lower limbs compared to the plyometric training achieved through various types of jumps, obtaining a greater progress, statistically significant, in 3 out of the 4 motor tests.

Keywords: depth jump training, plyometric training, athletics, strength.

Introduction

Training in athletics at puberty aims at strengthening the musculoskeletal system, which implicitly ensures an improvement in motor behavior by increasing the speed and precision of movements, following the full development of the children, also aiming to cultivate traits necessary for the full development of children. (Popescu et al., 2021).

In athletics, explosive strength is imperative for most athletics events, and training the lower body is the main concern of athletics specialists.

Plyometric training is a method used on a large scale to improve the conditional qualities of speed, strength, relaxation, and athletic performance both in children (Kotzmandis et al., 2000, Michailidis et al., 2013, Branet et al., 2021; Damian et al.,

2014), adolescents (Lloyd et al., 2012) and in adults. It should also be mentioned that most of the studies were conducted on adolescents and adults. specialized studies at early school age being limited in number. It has been proven that through adequate plyometric stimuli, with a frequency of 2-3 sessions per week, for 4-10 weeks, substantial gains in upper and lower train strength, movement speed and agility can be induced in athletes of the age range. Between 12-22 years; in addition, the safety of using this type of exercise has also been proven, provided that the intervention program is judiciously designed, without overtraining the athlete's musculoskeletal system. (Deng et al., 2023). However, there are studies which reported that plyometric exercises improve vertical jump power without improving sprint performance (Thomas, 2009, Markovic,

2007). In contrast, other studies (de Villarreal et al., 2008, Ramirez et al., 2022, Kryeziu et al., 2023) also reveal the improvement of sprinting after several weeks of plyometric training, even in those aged 7-9 years. (Bogdanis, 2019). The study carried out by Faigenbaum A.D. et al. (2009), reveals a significant improvement in the strength of the lower and upper body, but also in aerobic fitness in children aged between 8-11 years. The same conclusions are supported by other studies that highlight, "small improvements in anaerobic power and jumping, throwing and sprinting performance, and marked improvements in dynamic strength." (Ingle et al., 2006). Beneficial effects on sprinting with and without changes of direction, on jumping, were highlighted in early pubertal soccer players after only 8 weeks of plyometric work (Meylan et al., 2009), but also in children with health problems (Johnson et al., 2012; Marinescu et al., 2014).

Increasing running and jumping performance, following a program of 8-10 weeks, with 2 sessions per week with a minimum of 50-60 jumps per plyometric training session is possible in prepubertal children aged 5-14 years, and this type of training proved to be safe to use. The degree of improvement in explosive actions following a plyometric training of 4 weeks with a frequency of twice/week in untrained children seems to be determined by the age of the children: the older ones obtaining better results. (Marzouki et al., 2022); but there are also studies in which the inefficiency of plyometric work with a duration of 6 weeks on the vertical jump and the speed of 12-13-year-old football players has been proven (Kurt, 2023).

The use of depth jumps in the training of athletes proved to significantly improve the vertical jump and concentric contractile performance. (Gehri et al., 1998), "offer a greater degree of specificity related to power training in athletes."

Although plyometric training is accepted as an effective training method in most studies, the depth jump approach in training children is extremely limited; from what we know, there is only the study conducted by (Chelly et al., 2015) which revealed that plyometric

training for 10 weeks with a frequency of twice/week in which age-adapted depth jumps were used led to a significant improvement of acceleration and movement speed, of vertical and horizontal jumping, improved important components of athletic performance in 11-13 year old athletes.

Research purpose

The aim of this study was to investigate the effectiveness of a combined plyometric intervention program versus a plyometric program performed through age-adapted simple jumps.

Method

Subjects

The research was carried out in the athletics hall within the premises of the "Lia Manoliu" Sports Complex, Bucharest, which has appropriate equipment for training sessions and competitions organized by the Romanian Athletics Federation. The experiment took place over a period of 21 weeks, of which the first and last week were intended for the initial and final tests. The experimental group was made up of 10 children (6 girls + 4 boys), aged 12-13, enrolled in the School Sports Club number 5- Bucharest, with a minimum of 3 years of previous athletic training experience. It should be mentioned that the groups within the sports club are made up of a maximum of 12 athletes, which is why the research groups had a limited number of children; The control group consisted of 10 children (5 girls + 5 boys) of the same age.

Participants in this research were healthy people, who had no injuries that might have worsened during testing. Before the experiment, subjects were verbally informed about the testing particularities and the types of assessment used. All subjects agreed to how the experiment would be conducted.

Research methods

Statistical analyses was performed using the computer product IBM SPSS - Statistical Package for the Social Sciences.

In order to evaluate strength and speed, indirect evaluation methods were used - 4 motor tests like: Vertical jump, standing long jump, triple jump without jump (standing triple jump), penta jump without momentum (standing 5 bound test); each test was

performed 2 times, recording the best performance. The standing penta jump is a valid tool for assessing relaxation in athletes (Chamari et al., 2008) and for guiding young people towards explosive sports (Bouhlef, 2006).

Good results in the 4 motor tests have been correlated in the specialized literature with a high level of explosive power.

Training methodology

The subjects of the experimental group participated in 3 weekly trainings, lasting 90 minutes, each training session having two topics per lesson. Always in the second

weekly training, the second task had as its objective the development of strength in speed mode.

Within the 19 intervention programs for the development of relaxation, recourse was made to simple plyometric jumps and over obstacles, accessible to all ages, 6 sessions using plyometric means with loads (sandbags/medicine balls - 0.5kg); each weekly session also contained 2 series of 10 repetitions of deep jumps with landing on the ground in a flexion of 90°, followed by an active impulse of both legs on the ground.

Results

Table 1. **standing long jump** - initial testing - final testing - experimental group

Statistical indicators	TI	TF	Statistical indicators	
Media	191.10	198.10	Average difference (TF - TI)	7.00 3.7%
Standard deviation	13.92	14.78	Bilateral dependent t test	t - critic df
Minimum	174	180		2.26 9
Maximum	218	226		t p
Amplitude	44	46		14.16 <0.001
Variation coefficient	7.3%	7.5%	Effect size	4.48

In the standing long jump, (table 1 and figure 1), the average of the experimental values increased by 7.00 cm (3.7%), from 191.10 at the initial test to 198.10 cm at the final test. According to the dependent t significance test, the increase is statistically significant, $p < 0.001 < 0.05$ for $t = 14.16 > 2.26$ (critical t) and $df = 9$.

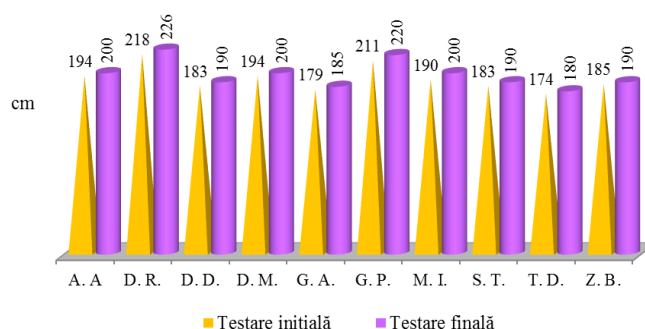


Fig. 1. - Athletes' results at the initial and final tests of the experimental group in standing long jump

Table 2. Triple jump without momentum - initial tests - final test - experimental group

Statistical indicators	TI	TF	Statistical indicators		
Media	523.90	544.50	Average differences (TF - TI)	20.60	3.9%
Standard deviation	30.17	32.61	Bilateral dependent t test	t - critic	df
Minimum	478	495		2.26	9
Maximum	575	600		t	p
Amplitude	97	105		20.11	<0.001
Variation coefficient	5.8%	6.0%	Effect size	6.36	

In the experimental group, the average of the values recorded at the triple jump without momentum, increased by 20.60 cm (3.9%), from 523.90 at the initial test, to 544.50 cm at the final test. According to the dependent t significance test, the increase is statistically significant, $p < 0.001 < 0.05$ for $t = 20.11 > 2.26$ (critical t) and $df = 9$. (table 2 and figure 2)

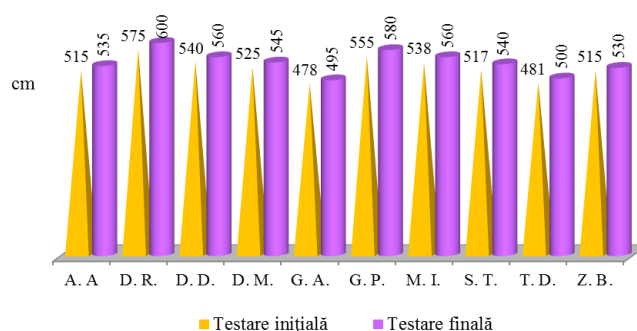


Fig. 2. - The results of the athletes at the initial and final tests of the **experimental group** in the triple jump without momentum.

Table 3. Penta jump without momentum - initial testing - final testing - experimental group

Statistical indicators	TI	TF	Statistical indicators		
Media	890.00	931.50	Average difference (TF - TI)	41.50	4.7%
Standard deviation	59.95	50.56	Bilateral dependent t test	t - critic	df
Minimum	795	840		2.26	9
Maximum	975	1010		t	p
Amplitude	180	170		5.97	<0.001
Variation coefficient	6.7%	5.4%	Effect size	1.89	

In the experimental group, the average of the values recorded in penta jump without momentum, increased by 41.50 cm (4.7%), from 890.00 at the initial test, to 931.50 cm at the final test. According to the dependent t significance test, the increase is statistically significant, $p < 0.001 < 0.05$ for $t = 5.97 > 2.26$ (critical t) and $df = 9$. (table 3 and figure 3)

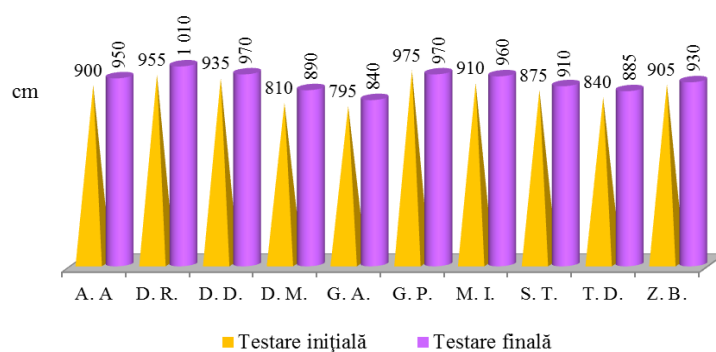


Fig. 3. - The results of the athletes at the initial and final tests in the penta jump test without momentum - the experimental group

Table 4. Vertical jump - initial tests - final tests - experimental group

Statistical indicators	TI	TF	Statistical indicators	
Media	30.20	34.50	Average difference (TF - TI)	4.30
Standard deviation	3.74	4.20		14.2%
Minimum	26	29	Bilateral dependent t test	t - critic
Maximum	37	43		df
Amplitude	11	14		2.26
Variation coefficient	12.4%	12.2%		t
				p
				14.33
			Effect size	<0.001
				4.53

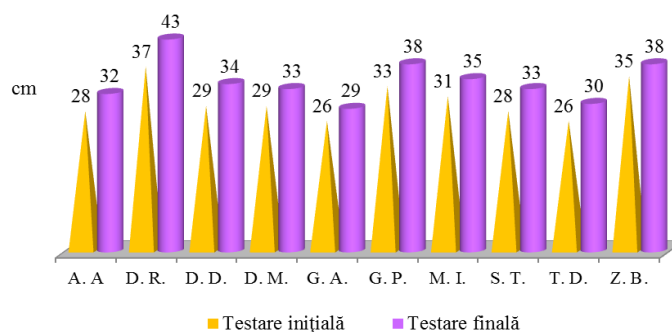


Fig. 4. - The results of the athletes at the initial and final tests in the vertical jump test.

In the experimental group, in the case of the vertical jump (table 4 and figure 4), the average of the recorded results increased by 4.30 cm (14.2%), from 30.20 at the initial test, to 34.50 cm at the final test.

According to the dependent t significance test, the increase is statistically significant, $p < 0.001 < 0.05$ for $t = 14.33 > 2.26$ (critical t) and $df = 9$.

Table 5. **standing long jump - initial testing - final testing - control group**

Statistical indicators	TI	TF	Statistical indicators	
Media	188.80	193.00	Average difference (TF - TI)	4.20 2.2%
Standard deviation	10.12	11.11	Bilateral dependent t test	t - critic df
Minimum	173	175		2.26 9
Maximum	205	210		t p
Amplitude	32	35		9.00 <0.001
Variation coefficient	5.4%	5.8%	Effect size	2.85

In the control group, in the case of standing long jump (table 5 and figure 5), the average of the results increased by 4.20 cm (2.2%), from 188.80 at the initial test to 193.00 cm at the final test. According to the dependent t significance test, the increase is statistically significant, $p < 0.001 < 0.05$ for $t = 9.00 > 2.26$ (critical t) and $df = 9$

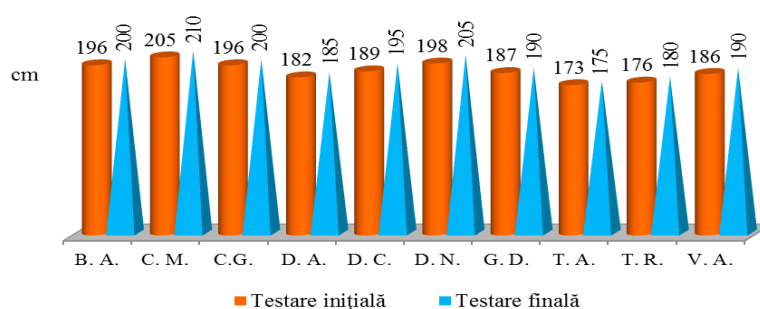


Fig. 5. The results of the athletes at the initial and final tests - the control group at the standing long jump.

Table 6. **triple jump without momentum -initial testing - final testing - control group**

Statistical indicators	TI	TF	Statistical indicators	
Media	496.00	514.00	Average difference (TF - TI)	18.00 3.6%
Standard deviation	17.93	21.32	Bilateral dependent t test	t - critic df
Minimum	466	480		2.26 9
Maximum	530	550		t p
Amplitude	64	70		12.32 <0.001
Variation coefficient	3.6%	4.1%	Effect size	3.90

In the triple jump test without momentum, the mean of the control group increased by 18.00 cm (3.6%), from 496.00 at the initial test to 514.00 cm at the final test. According to the dependent t significance test, the increase is statistically significant, $p < 0.001 < 0.05$ for $t = 12.32 > 2.26$ (critical t) and $df = 9$. (table 6 and figure 6)

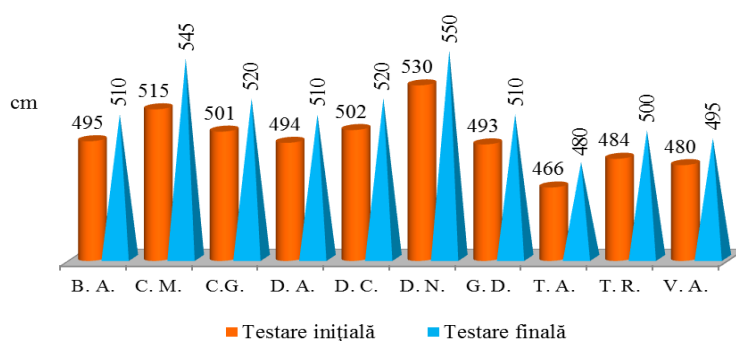


Fig. 6. - The results of the athletes at the initial and final tests - the control group in triple jump without momentum.

Table 7. **Control group - Control group - initial tests - final tests - pentasault without momentum**

Statistical indicators	TI	TF	Statistical indicators		
Media	876.30	909.50	Average difference (TF - TI)	33.20	3.8%
Standard deviation	27.37	30.23	Bilateral dependent t test	t - critic	df
Minimum	820	850		2.26	9
Maximum	910	950		t	p
Amplitude	90	100		30.09	<0.001
Variation coefficient	3.1%	3.3%	Effect size		9.51

The mean of the control group, in the five hop without momentum, the control group, increased by 33.20 cm (3.8%), from 876.30 at the initial testing, to 909.50 cm at the final testing. According to the dependent t significance test, the increase is statistically significant, $p < 0.001 < 0.05$ for $t = 30.09 > 2.26$ (critical t) and $df = 9$. (table 7 and figure 7)

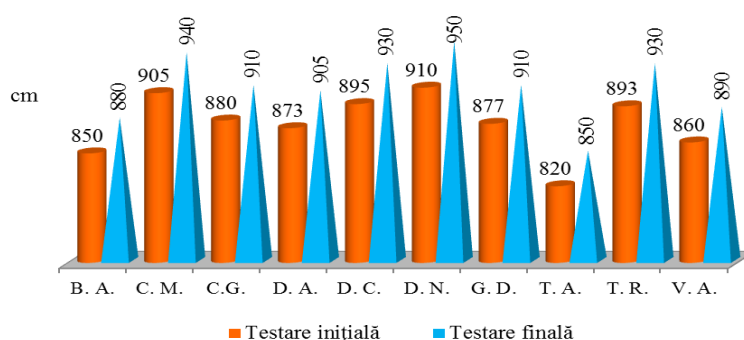


Fig. 7 - The results of the athletes at the initial and final tests - at the penta jump test without momentum - the control group.

Table 8. **Control group - initial testing - final testing - vertical jump**

Statistical indicators	TI	TF	Statistical indicators		
Media	27.20	31.20	Average difference (TF - TI)	4.00	14.7%
Standard deviation	2.15	2.44	Bilateral dependent t test	t - critic	df

Minimum	24	27	2.26	9
Maximum	31	36	t	p
Amplitude	7	9	18.97	<0.001
Variation coefficient	7.9%	7.8%	Effect size	6.00

The control group's mean vertical jump results increased by 4.00 cm (14.7%), from 27.20 at initial testing to 31.20 cm at final testing. According to the dependent t significance test, the increase is statistically significant, $p < 0.001 < 0.05$ for $t = 18.97 > 2.26$ (critical t) and $df = 9$. (table 8 and figure 8)

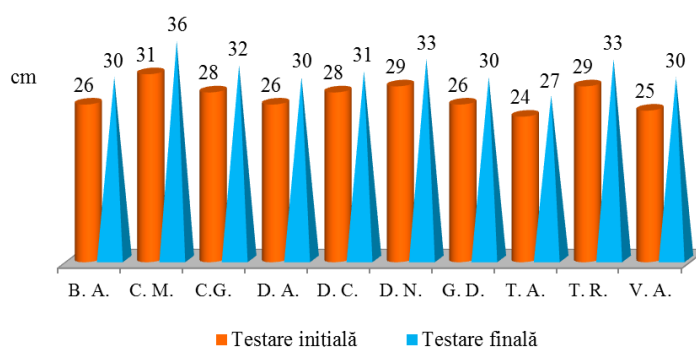


Fig. 8. - Results of the two vertical jump tests of the control group.

Table 9- Statistical indicators - **Comparison of progress of the experimental group vs the control group - Standing long jump**

Statistical indicators	Differences (F-I)		SIGNIFICANCE TESTS		
	Experiment	Control			
Media	7.00	4.20	Levene Test	F	0.08
Standard deviation	1.56	1.48		Sig.	0.776
Minimum	5	2		equal dispersions	
Maximum	10	7	Bilateral independent test t	t critic	2.10
Amplitude	5	5		t	4.12
Variation coefficient	22.3%	35.1%		p	< 0.001
				df	18

The average progress recorded by the experimental group for standing long jump measurements is 7.00 cm. In the control group, the progress was 4.20 cm. Independent t-test (table 9) for equal variances shows that the two mean values are significantly different, $p = 0.001 < 0.05$ for $t = 4.12$ and $df = 18$. The control group made significantly less progress.

Table 10- Statistical indicators - Progress comparison of the experimental group vs the control group - triple jump without momentum

Statistical indicators	Differences (F-I)		SIGNIFICANCE TESTS		
	Experiment	Control			
Media	20.60	18.00	Levene Test	F	0.16
Standard variation	3.24	4.62		Sig.	0.697
Minimum	15	14		equal dispersions	
			Bilateral	t critic	2.10

Maximum	25	30	independent test t	t	1.46
Amplitude	10	16		p	0.162
Variation coefficient	15.7%	25.7%		df	18

In the triple jump test, the average progress achieved by the experimental group is 20.60 cm (table 10). In the control group, the progress was 18.00 cm. The independent t-test for equal variances shows that the two mean values are not significantly different, $p=0.162 > 0.05$

Table 11- Statistical indicators - Progress comparison of the experimental group vs the control group - pentasault without momentum

Statistical indicators	Differences (F-I)		SIGNIFICANCE TESTS		
	Experiment	Control		F	6.64
Media	41.50	33.20	Levene Test	Sig.	0.019
Standard deviation	21.99	3.49		nonequal dispersions	
Minimum	-5	30		t critic	2.10
Maximum	80	40	Bilateral independent test t	t	1.18
Amplitude	85	10		p	0.267
Variation coefficient	53.0%	10.5%		df	9

In the experimental group, the average progress achieved by the experimental group in penta jump is 41.50 cm (table 11). In the control group, the progress was 33.20 cm. Independent t-test for unequal variances shows that the two mean values are not significantly different, $p=0.267 > 0.05$ for $t=1.18$ and $df=9$. The control group made less progress.

Table 12- Statistical indicators - Comparison of progress of the experimental group vs the control group - vertical jump

Statistical indicators	Differences (F-I)		SIGNIFICANCE TESTS		
	Experiment	Control		F	2.47
Media	4.30	4.00	Levene Test	Sig.	0.134
Standard deviation	0.95	0.67		equal dispersions	
Minimum	3	3		t critic	2.10
Maximum	6	5	Bilateral independent test t	t	0.82
Amplitude	3	2		p	0.424
Variation coefficient	22.1%	16.7%		df	18

In the experimental group, the average progress achieved by the experimental group in the vertical jump is 4.30 cm (table 12). In the control group, the progress was 4.00 cm. Independent t-test for equal variances shows that the two mean values are not significantly different, $p=0.424 > 0.05$ for $t=0.82$ and $df=18$. The control group made less progress.

Conclusion

After statistical processing, it appeared that combined plyometric training hebdomadar for 19 weeks in which depth jumps, over obstacles, with and without loads were used,

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All authors have equally contributed to this study and should be considered as main authors.

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