10.2478/tperj-2024-0001

Enhancing Physical and Technical Performance in Sport Games through the Implementation of Plyometric Exercise Programs

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Abstract

Aim. The aim of the study was to implement a training program consisting of plyometric exercises using modern technologies to improve the explosive strength of junior basketball players.
Material and method. The study addresses this necessity by investigating the transformative impact of a customized plyometric training program on the explosive strength of 19 female basketball players aged 10 to 12. In the study, a two-month program of specific plyometric development exercises adapted to the basketball game was implemented, focused on improving the key parameters of explosive resistance. Specifically, improvements in flight time and height, assessed through five specific tests: Squat Jump Test, Drop Jump Test, Stiffness Test, 15 seconds Jump Test, 30 seconds Jump Test.
Results. In all 5 tests, the recorded progress was statistically significant compared to the reference value $p < 0.05$. Cohen's values reflect a very large effect size > 0.8 for all tests with one exception for the Stiffness Test where the effect size was only large in the 0.5-0.8 range.
Conclusions. The research contributes valuable insights into age-specific athletic development, advocating for the optimization of physical and technical readiness in young basketball players through targeted plyometric training sessions.

***Key words**: plyometric training; explosive strength; youth athletes; basketball performance.*

Rezumat

Scop. În tendinţele evolutive ale antrenamentului atletic, semnificaţia programelor de exerciţii pliometrice a devenit din ce în ce mai pronunţată.
Material şi metodă. Studiul abordează această necesitate prin investigarea impactului transformator al unui program de antrenament pliometric personalizat asupra forţei explozive a 19 jucătoare de baschet cu vârste cuprinse între 10 şi 12 ani. Pe parcursul unui program de antrenament concentrat de două luni, analizele statistice au descoperit îmbunătăţiri demne de remarcat în cheie. parametrii rezistenţei explozive. Mai exact, îmbunătăţiri ale timpului de zbor şi al înălţimii, evaluate prin cinci teste specifice: Test de săritură în ghemuit, Test de săritură în cădere, Test de rigiditate, Test de săritură de 15 sec., Test de săritură de 30 de sec.
Rezultate. În toate cele 5 teste, progresul înregistrat a fost semnificativ statistic în comparaţie cu valoarea de referinţă $p < 0,05$. Valorile lui Cohen reflectă o mărime foarte mare a efectului > 0,8 pentru toate testele, cu o excepţie pentru Testul de rigiditate, unde dimensiunea efectului a fost doar mare în intervalul 0,5-0,8.
Concluzii. Cercetarea contribuie cu perspective valoroase asupra dezvoltării atletice specifice vârstei, susţinând optimizarea pregătirii fizice şi tehnice la tinerii jucători de baschet prin sesiuni de antrenament pliometrice.

***Cuvinte cheie**: antrenament pliometric; puterea explozivă; tineri sportivi; performanţă in baschet.*

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Introduction

It is self-evident that athletes seek ways to enhance their performance in terms of explosive strength since most sports involve rapid movements, for which power needs to be generated quickly (Chu et al, 2013; Hansen et al, 2010). Plyometrics is a type of training that employs exercises to produce rapid and powerful movements, aiming to improve the functions of the nervous system, generally with the goal of enhancing athletic performance (Asadi, 2013; Attene et al, 2015; Bouteraa et al, 2020; Nikolic, 2018). Plyometric movements, where a muscle is loaded and then contracts very rapidly, utilize the force, elasticity, and innervation of muscles and surrounding tissues to jump higher, run faster, throw farther, or hit harder, depending on the specific training objective (Chen et al, 2018; Meszler et al, 2015; Yılmaz, 2022). The plyometric training is used to increase the speed or force of muscle contractions, often with the goal of improving the height of a jump (Aksović et al, 2019, Aksovićet al, 2021; Erculj et al, 2010).

Plyometrics consists in exercises that allow a muscle to reach maximum force in a short period of time. This ability of speed and strength is known as explosive force/power. In its purest form, a plyometric exercise leverages the body's natural response to the rapid stretching of muscles. This response has been termed the stretch-shortening cycle (Komi, 2000), or the myotatic reflex. Research has shown that a muscle rapidly stretched before contraction will contract and shorten more forcefully and quickly, creating positive adaptations for strength, power, and speed (De Villarreal et al, 2010; Komi, 2000). For instance, a basketball player preparing for a rebound will lower their center of gravity before executing the jump to recover the ball. Similarly, a volleyball player will perform the same downward movement of the center of gravity before jumping to block a ball sent by an opponent (Silva, 2019). It is a natural response of the human body to load before making an explosive movement. Thus, we witness the benefits of plyometric activity in every sports-related endeavor (Davies et al, 2015; Nikolic, 2018).

Objectives of study:

- Design and implementation of a training program consisting of plyometric exercises aimed at achieving a significant improvement in the explosive strength of junior basketball players.
- Validation of the proposed program through contemporary equipment and technologies, and its enhancement for maximum efficiency.

Materials and methods

Study participants

The research included a total of 19 female athletes, all belonging to a single group, namely the experimental group. This group consists of basketball players, from the Sports School Club in Sibiu, aged between 10 and 12 years old.

Study design

The study involved the administration of 5 standardized tests using the Optojump Next system. The research took place from October to December 2022, and was phased as follows:

- from October 10, 2022, to October 16, 2022, initial tests were conducted;
- from October 17, 2022, to December 11, 2022, the plyometric training program was implemented over a period of 2 months, involving a total of 16 training sessions, with 2 sessions per week;
- from December 12, 2022, to December 17, 2022, final tests were conducted.

Measurements

The research included a series of standardized tests, and these assessments were facilitated by leveraging the capabilities of the Optojump system:

- *Squat Jump Test.* Test Objective: Assessment of explosive strength in the lower limbs. Execution of the test: It involves a single jump from a squatting position (angle of 90° at the knee) with hands on hips and without counter movement.
- *Drop jump Test.* Test Objective: Evaluation of explosive strength in the lower limbs. Execution of the test: Performing 1 jump starting from a mat at a preset height from the ground (40cm).
- *Stiffness Test.* Test Objective: Assessment of reactive strength. Execution of the test: Performing 7 jumps with straight knees.
- 15 seconds Jump Test. Test Objective: Evaluation of anaerobic strength. Execution of the test: Performing 15 seconds of jumps.
- *30 seconds Jump Test.* Test Objective: Evaluation of anaerobic strength. Execution of the test: Performing 30 seconds of jumps.

Statistical analysis

The research statistical analysis using SPSS 20,: arithmetic mean, standard deviation (SD), one sample t- Student test, standard error mean (SEM). The study deemed a significance threshold of $p<.05$, corresponding to a 95% confidence interval (CI), as relevant. The effect size was calculated by Cohen's and interpreted as follows: below 0.3 small effect, 0.3-0.5 medium effect, 0.5-0.8 large effect, over 0.8 very large effect.

Results

After analyzing the obtained results, it is observed that the vast majority of subjects who participated in this study have significantly improved results in terms of plyometrics. The parameters that were monitored throughout the experiment are: flight time and jump height. Through the analysis of the results within the experiment for the Squat Jump Test, it can be observed that the arithmetic means for both parameters, flight time and height improved. For the flight time parameter, the results obtained in the final testing are 0.045 seconds better, while for the height parameter, an increase of 5.231 cm has been recorded (Table I).

Table I. Statistical analysis of the results in the Squat Jump Test

Parameter	Arithmetic Media	SD	SEM	95% CI		t	p	Cohen`s
				Lower	Upper			
Flight Time (s) Tf-Ti	.045	.033	.007	.061	.029	5.859	.000	1.448
Height (cm) Tf-Ti	5.231	2.600	.596	6.485	3.978	8.769	.000	1.723

SD – Standard Deviation; SRM - Std. Error Media, CI – interval of confidence, t–Student test, p–statistical significance

At the Drop Jump Test within the preliminary experiment, the difference in arithmetic means recorded between the initial and final testing highlighted a statistically significant progress for both parameters. In terms of the flight time parameter, there has been an improvement of 0.040 seconds, while for the jump height parameter, there has been an improvement of 3.805 centimeters (Table II).

Table II. Statistical analysis of the results in the Drop Jump Test

Parameter	Arithmetic Media	SD	SEM	95% CI		t	p	Cohen`s
				Lower	Upper			
Flight Time (s) Tf-Ti	.040	.037	.008	.059	.022	4.727	.000	1.181
Height (cm) Tf-Ti	3.805	3.420	.784	5.453	2.156	4.849	.000	1.158

SD – Standard Deviation; SRM - Std. Error Media, CI – interval of confidence, t –Student test, p –statistical significance

The difference in arithmetic means recorded in the Stiffness Test within the final experiment between both assessments highlighted a statistically significant progress for the parameters of flight time and height. The flight time parameter shows an improvement of 0.020 seconds in the final testing and an increase of 2.047 centimeters for the jump height parameter (Table III).

Table III. Statistical analysis of the results in the Stiffness Test

Parameter	Arithmetic Media	SD	SEM	95% CI		t	p	Cohen`s
				Lower	Upper			
Flight Time (s) Tf-Ti	.020	.029	.006	.034	.006	3.073	.007	0.576
Height (cm) Tf-Ti	2.047	2.526	.579	3.265	.829	3.532	.002	0.617

SD – Standard Deviation; SRM - Std. Error Media, CI – interval of confidence, t –Student test, p –statistical significance

At the 15 seconds Jumps Test, the difference in recorded means between the two assessments highlighted a statistically significant progress for both parameters. The arithmetic mean of the flight time parameter shows an improvement of 0.020 seconds, and for the jump height parameter, there is an improvement of 2.294 centimeters in the obtained results (Table IV).

Table IV. Statistical analysis of the results in the 15 seconds Jumps Test

Parameter	Arithmetic Media	SD	SEM	95% CI		t	p	Cohen`s
				Lower	Upper			
Flight Time (s) Tf-Ti	.024	.018	.004	.033	.015	5.791	.000	0.861
Height (cm) Tf-Ti	2.294	1.730	.396	3.128	1.460	5.781	.000	0.847

SD – Standard Deviation; SRM - Std. Error Media, CI – interval of confidence, t –Student test, p –statistical significance

Within the experiment, in the 30 seconds Jumps Test, the difference in arithmetic means recorded between the initial and final testing highlighted a significant progress for the flight time and height parameter. The arithmetic mean of the flight time parameter has improved by 0.030 seconds, and for the jump height parameter, there is an improvement of 2.568 centimeters (Table V).

Table V. Statistical analysis of the results in the 30 seconds Jumps Test

Parameter	Arithmetic Media	SD	SEM	95% CI		t	p	Cohen`s
				Lower	Upper			
Flight Time (s) Tf-Ti	.030	.022	.005	.041	.019	5.718	.000	1.089
Height (cm) Tf-Ti	2.568	1.930	.442	3.498	1.637	5.799	.000	1.094

SD – Standard Deviation; SRM - Std. Error Media, CI – interval of confidence, t–Student test, p –statistical significance

Discussions

The results of the study highlight the fact that by adapting and implementing plyometric exercises you can improve the height of jumps and flight time, important parameters for explosive strength. The present study aimed to investigate the impact of a plyometric training program on the explosive strength of female basketball players aged 10 to 12 years. The plyometric exercises in this study focused on leveraging the stretch-shortening cycle, a natural response of muscles to rapid stretching before contraction. The results of the study, as analyzed through various tests, revealed significant improvements in explosive strength among the participants.

Our study aligns with previous studies and contributes to the understanding of the influence of plyometric training on explosive strength in athletes.

Plyometrics in basketball training is vital for enhancing players' explosive power, agility, and jumping capabilities. It specifically targets the dynamic movements required in basketball, such as quick sprints, sharp changes in direction, and explosive jumps for shots or rebounds (Asadi, 2013; Erculj et al 2010; Ramirez-Campillo et al, 2022; Robertl et al, 2013). This training method directly translates to improve on-court performance, helping players execute swift and powerful actions essential for success in the game.

Applying appropriate plyometric exercises, their correct dosage, emphasizing proper execution, and incorporating adequate rest between sets and repetitions can undoubtedly enhance the explosive capacity of basketball players. The results of all studies included in the work 'Plyometric basketball training' (Nikolic , 2018), with the exception of one, unequivocally suggested that plyometric exercise-based training within a limited time frame brings statistically significant improvements to the studied parameters. The obtained results suggest that planned plyometric training carried out within a specific time period has positive and statistically significant effects on the development of explosive capacity in basketball; what was highlighted by previous studies (Correia et al, 2020; Moanta et al. 2014; Olteanu et al, 2020; Olteanu et al., 2023).

It was found that using a plyometric training program for 12 weeks and progressively increasing the intensity of the workouts leads to improvements in gross motor coordination and physical fitness (Almeida, 2021; Chen et al, 2018; Meszler et al, 2019). Additionally, the conclusions of this study suggest that to enhance gross motor coordination among children, training programs should focus on improving their physical abilities. The approach to the effects of the training process on the motor capacity of athletes must be approached interdisciplinary to analyze the impact of all decisive factors (Badau et al, 2010; Badau et al., 2022; Cojanu et al, 2022; Martoma, 2009; Martoma, 2010; Nechita, 2012; Tudor et al., 2014).

The limitations of the study. The study included a relatively small sample size of 19 female basketball players aged 10 to 12 years. While the results demonstrated significant improvements, the generalization of our findings to a larger population may be limited. Future studies with more extensive and diverse participant groups could enhance the external validity of the findings. The participants were exclusively female basketball players. While this specificity allowed for a focused investigation within a particular sport, it limits the generalizability of the results to athletes in different sports. Further studies with a diverse range of sports could provide insights into the transferability of training effects across various athletic disciplines.

The strengths of this study. The study employed a diverse set of standardized tests to assess explosive strength. This comprehensive approach provided a holistic evaluation of the impact of the integrated training program, offering nuanced insights into the multifaceted aspects of athletic performance. The use of the Optojump Next system for standardized tests added objectivity and precision to the measurements of parameters such as flight time and height. This minimized potential biases associated with subjective assessments and increased the reliability of the results.

Conclusions

In conclusion, the findings suggest that the integration of plyometric exercises in the training process positively influences explosive strength in young female basketball players. The study provides

valuable insights for coaches and trainers working with youth athletes, emphasizing the importance of incorporating multifaceted training programs to enhance overall athletic performance. The selection and implementation of a training program consisting of plyometric exercises, tailored to the age-specific characteristics of the participating subjects, and shaped through specific testing, lead to the optimization and improvement of explosive strength, which is specific to the game of basketball. Additionally, through the analysis of the data obtained the subjects achieved better results in the final testing compared to the initial testing. All the data gathered from the application of the tests point towards conclusions that suggest training activities in basketball can be enhanced by implementing a training program that uses plyometric exercises, exerting a beneficial effect on the physical and technical preparation of the players. The study not only underscores the importance of age-appropriate training, but also helps in understanding the benefits of plyometric in youth sports. Future research could explore the long-term effects and sustainability of such integrated training approaches across diverse sports and age groups.

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