Vol. XXVII, Issue 1/ 2026

GYMNASIUM

Scientific Journal of Education, Sports, and Health

Original Article

Analysis of the Impact of Functional Training on Explosive Strength in Young Athletes Using the Optojump System

Alecu, Stefan [1*]

[1]*Transilvania University of Brașov, Bd. Eroilor 29,Brașov, 500036, Romania*

DOI: 10.29081/gsjesh.2026.27.1.6

Keywords: *functional training; explosive strength; Optojump; adolescent athletes; basketball*

Abstract

The purpose of this study was to investigate the effects of an eight-week functional training program on the development of explosive strength in adolescent basketball players. A total of 32 athletes (15 girls and 17 boys, aged 14–17 years) participated in the study. The evaluation was carried out using the Optojump system, applying three standardized tests: Countermovement Jump (CMJ), Repeated Jumps (RJ5), and Squat Jump (SJ). Athletes were tested before and after the intervention, and statistical analysis was performed using SPSS v26. Results indicated significant improvements in all tests for both sexes ($p < 0.001$), with mean increases between 1.8 and 2.7 cm. Effect sizes were large (Cohen's $d > 1.0$), and confidence intervals confirmed the robustness of the findings. The results demonstrate that functional training is an effective and safe method for optimizing explosive strength and vertical jump in adolescent basketball players, supporting its integration into long-term athletic development programs.

1. Introduction

The development of explosive strength represents one of the essential components of performance in modern sports games, especially in basketball, where actions such as rebounding, contested shooting, or blocking require high levels of vertical jump and reactive ability (Bosco, C., Luhtanen, P., & Komi, P.V., 1983). Among adolescent athletes, this aspect becomes even more important, as the period of biological development provides a "critical window" for optimizing neuromuscular qualities (Cohen, D. et al., 2021; Harper, D. J., Cohen, D. D., Rhodes, D., Carling, C., & Kiely, J., 2022) and for preventing imbalances that may lead to injuries (Lloyd et al., 2015).

Functional training has become, in recent decades, an increasingly used

* *E-mail*: alecu.stefan@unitbv.ro, tel.0742098048

method in athlete preparation (Onea, G. A., & Balint, L., 2017), by emphasizing complex, multi-joint exercises that reproduce sport-specific movements and simultaneously require strength, stability, and coordination (Behm, D.G., Faigenbaum, A.D., Falk, B., & Klentrou, P., 2008). By integrating plyometric exercises and core stability drills, functional training contributes to the development of the kinetic chain in an integrated way, facilitating the transfer of acquired qualities into the specific context of competition (Granacher et al., 2016).

In this context, explosive strength is closely related to the efficiency of the stretch-shortening cycle (SSC), a biomechanical mechanism that enables the conversion of elastic energy into additional mechanical energy during jumps and changes of direction (Komi, 2000). The ability to optimally utilize the SSC can be measured through indicators such as the Reactive Strength Index (RSI), obtained through repeated jump tests, which provide relevant information for monitoring young athletes' performance (Read & Lloyd, 2014).

Numerous studies have shown that introducing plyometric and functional exercises to school-aged athletes has positive effects not only on performance but also on injury prevention, by increasing neuromuscular control (Onea, G. A., Balint, L., & Pascu, M., 2017) and joint stability (Myer et al., 2011; Faigenbaum et al., 2009). Furthermore, in basketball, such training has been associated with improved vertical jump performance and greater efficiency in specific game actions (Zemkova & Hamar, 2010).

Beyond the methodological component, monitoring athletes' progress requires objective and reliable tools. The Optojump Next system (Microgate) is widely used in sports research for evaluating vertical jump parameters (contact time, flight time, jump height), and is considered a valid and reproducible instrument (Glatzel et al., 2020). Its use allows for a detailed and precise analysis of the changes induced by a training program and provides coaches and researchers with objective data for validating interventions (Teris, S., Lakotos, I. I., Koronas, V., 2024).

Thus, considering the importance of explosive strength in basketball, the high potential for development during adolescence, and the effectiveness of functional training (Hernández-Lougedo, J. et al., 2021; Soriano, M. A., Boullosa, D., & Amaro-Gahete, F., 2022; Xiao, W. et al., 2021; Badau, A., 2019) supported by plyometric exercises, the present research aims to investigate the effects of an 8-week functional training program on vertical jump performance, measured through the CMJ, RJ5, and SJ tests using the Optojump system, in adolescent athletes registered with a basketball club in Brașov.

2. Materials and Methods

The purpose of this study was to evaluate the effects of an eight-week functional training program on the development of explosive strength in adolescent basketball athletes, using Optojump technology. The working hypothesis was that functional training can significantly improve vertical jump performance, measured through standardized tests with the Optojump system.

Participants: The study included 32 athletes (15 girls and 17 boys), aged between 14 and 17 years, registered with a basketball sports club in Brașov. All participants were clinically healthy, had at least two years of competitive experience, and trained regularly (3–5 sessions per week). Parental approval and informed consent from the athletes were obtained, in accordance with the Declaration of Helsinki on research ethics involving minors.

Experimental design: Participants underwent both initial and final testing using the Optojump Next system (Microgate) to measure explosive strength through the following three standardized tests:

1. Countermovement Jump (CMJ) – measures jump height and flight time, reflecting the explosive strength of the lower limbs.

2. Five Repeated Jumps (RJ5) – assesses reactive capacity and muscle elasticity through the calculation of the Reactive Strength Index (RSI).

3. Squat Jump (SJ) – performed from a static half-squat position without countermovement, to highlight pure concentric strength.

Intervention protocol: The athletes followed an eight-week functional training program (outlined in Table 1), integrated into their regular training routine. Sessions were carried out three times per week, each lasting approximately 45 minutes. The training structure was progressive, adapted to each athlete's level, and aimed to avoid overtraining.

Table 1. *Intervention Program – 8-Week Functional Training*

Phase	Weeks	Main Objective	Recommended Functional Exercises	Sets × Reps
1. Neuromuscular adaptation	1–2	Learning technique, stability, preparation for plyometrics	1. Bodyweight squats 2. Forward lunges with trunk rotation 3. Jumps in place with arms overhead 4. Plank + arm/leg lift 5. Single-leg glute bridge	3×12 3×10/side 3×10 3×30 sec 3×12/side
2. Basic strength development	3–4	Increasing concentric–explosive strength and stability	1. Squat Jump 2. Explosive step-up on bench 3. Lateral jumps over small hurdle (30 cm) 4. Side plank with hip lift 5. Overhead medicine ball throw	4×8 3×10/side 4×12 3×12/side 3×10
3. Plyometrics and power	5–6	Activation of stretch–shortening cycle, reactive jumps	1. Drop Jump from bench (40 cm) 2. Depth jump + vertical jump 3. RJ5 – 5 consecutive jumps 4. Jumping lunges 5. Dynamic plank on medicine ball	4×8 3×10 4 reps 3×10/side 3×12
4. Integration and basketball-specific	7–8	Transfer to game situations, maximum vertical jump	1. Jumps to the backboard with ball 2. Direction-change jumps 3. Plyometric circuit (drop jump + 10 m sprint + change of direction) 4. Medicine ball slam jump 5. Integrated core (plank + medicine ball throw)	4×8 4×6/side 6 reps 3×8 3×10

Data collection and processing: The Optojump system recorded indicators such as jump height (cm), contact time (s), flight time (s), and RSI (Reactive Strength Index). Each participant performed three valid repetitions for each test, and the best result was retained for analysis.

The final analysis showed that 28 athletes recorded progress (between 3%

and 15%), 2 remained unchanged, and 2 showed minor regression (~5%), which confirms the overall effectiveness of the applied program.

3. Results and discussions

Statistical analysis was performed using IBM SPSS v26. Mean, standard deviation (SD), minimum and maximum values, and coefficient of variation (CV%) were calculated for each test and gender. To compare results between the initial and final testing, the paired-samples t-test was used, with the level of significance set at $p < 0.05$. Effect size was determined using Cohen's d, and estimation precision was assessed with 95% confidence intervals (CI95%). To verify assumptions, the distribution of differences between testings was analyzed using the Shapiro-Wilk test.

In Table 1, the mean values (X) obtained in all three tests (CMJ, RJ5, SJ) show a consistent increase from initial testing (IT) to final testing (FT), both in boys and girls.

- CMJ: boys improved from 27.74 cm to 29.68 cm, while girls improved from 29.18 cm to 31.33 cm.
- RJ5: boys increased from 31.03 cm to 33.72 cm, girls from 28.26 cm to 30.08 cm.
- SJ: boys improved from 31.36 cm to 33.53 cm, girls from 29.82 cm to 32.42 cm.

Inferential analysis shows that all differences are statistically significant ($p = 0.000$, in all cases), confirmed by the high t values (between 4.5 and 6.0). This demonstrates that the recorded changes are not random but the result of the applied training program.

The coefficient of variation (CV%) ranged between 14% and 21%, indicating moderate variability within the groups, typical for adolescents in a developmental phase. However, the reduction in CV% in boys for CMJ (from 16.33% to 14.08%) suggests better performance homogeneity after the intervention.

Table 2. *Descriptive statistics for the Optojump tests*

Test	Gender	IT/FT	X (cm)	Min	Max	SD	t	p	CV%
CMJ	M	IT	27.74	20.82	36.34	4.53	5.562	0.000	16.33
		FT	29.68	22.92	36.34	4.18	5.562	0.000	14.08
CMJ	F	IT	29.18	20.69	39.74	5.29	4.546	0.000	18.13
		FT	31.33	22.79	44.61	6.40	4.546	0.000	20.43
RJ5	M	IT	31.03	21.81	38.49	5.36	6.039	0.000	17.27
		FT	33.72	24.65	43.70	6.42	6.039	0.000	19.03
RJ5	F	IT	28.26	21.27	39.39	5.89	4.518	0.000	20.84
		FT	30.08	22.70	44.24	6.12	4.518	0.000	20.34
SJ	M	IT	31.36	20.74	39.44	6.17	4.832	0.000	19.67
		FT	33.53	22.88	45.17	6.87	4.832	0.000	20.49
SJ	F	IT	29.82	20.73	39.82	6.47	4.541	0.000	21.70
		FT	32.42	23.52	45.00	6.63	4.541	0.000	20.45

IT – initial testing, FT – final testing, Min – minimum, Max – maximum, SD – standard deviation, t – paired-samples t-test, p – significance level, CV% – coefficient of variation.

The results presented in Table 2 show that the eight-week functional training program produced significant and consistent effects on explosive strength, confirmed by the large values of Cohen's d, the positive confidence intervals, and the validation of normality through the Shapiro-Wilk test.

Countermovement Jump (CMJ). Boys ($d = 1.349$, $\Delta X = +1.94$ cm): very large effect, with an increase in jump height confirmed by the 95% CI (1.25 – 2.62 cm). This indicates a clear improvement in explosive strength in the extensor chain of the lower limbs. Girls ($d = 1.174$, $\Delta X = +2.15$ cm): large effect, with a slightly wider confidence interval (1.22 – 3.07 cm), showing greater variability. This result suggests good neuromuscular adaptation (Onea, G. A., Balint, L., & Oprea, D., 2018) to concentric and elastic exercises.

The CMJ confirms that both boys and girls significantly improved their vertical jump performance. Mean increases of over +2 cm are practically relevant for basketball, where even a few centimeters can influence success in rebounding or contested shots.

Repeated Jumps Test (RJ5). Boys ($d = 1.465$, $\Delta X = +2.69$ cm): the largest effect among all tests, showing significant development of reactive capacity and stretch–shortening cycle efficiency. The confidence interval (1.82 – 3.56 cm) confirms the robustness of this progress. Girls ($d = 1.186$, $\Delta X = +1.82$ cm): large effect, though smaller than in boys, which can be explained by differences in muscle mass and neuromuscular recruitment. Nevertheless, the progress remains significant and indicates a clear improvement in RSI (Reactive Strength Index). The RJ5 results show that boys benefited more from the plyometric and reactive components of the program, suggesting more efficient adaptation to explosive impact exercises. For girls, the progress is relevant but more moderate, indicating that reactive exercises should be integrated carefully and progressively.

Squat Jump (SJ). Boys ($d = 1.255$, $\Delta X = +2.17$ cm): large effect, with a clear increase in pure concentric strength. This result demonstrates that training effectively stimulated force production without elastic contribution. Girls ($d = 1.204$, $\Delta X = +2.60$ cm): large effect and an even greater increase than in boys, suggesting that girls responded better to concentric-type exercises. The confidence interval (1.42 – 3.78 cm) confirms the robustness of the progress. The SJ shows that both groups significantly developed concentric–explosive strength. The better results in girls suggest that they exploited functional and controlled-load plyometric exercises more effectively.

Shapiro-Wilk test (normality). In all cases, p-values were > 0.05 (between 0.389 and 0.758), confirming that the distributions of the differences were normal and that the use of the paired-samples t-test was valid. This further strengthens the robustness of the statistical conclusions and rules out the risk of errors related to the nature of the data.

Table 3. *Effect size and Shapiro-Wilk normality test for CMJ, RJ5, and SJ performances*

Test	Gender	d	ΔX (cm)	IC95%		p
				Lower	Higher	
CMJ	M	1.349	1.94	1.25	2.62	0.445
CMJ	F	1.174	2.15	1.22	3.07	0.758
RJ5	M	1.465	2.69	1.82	3.56	0.578
RJ5	F	1.186	1.82	1.04	2.59	0.389
SJ	M	1.255	2.17	1.35	3.00	0.736
SJ	F	1.204	2.60	1.42	3.78	0.694

d – Cohen's d value, ΔX – mean difference, CI – confidence interval, p – Shapiro-Wilk normality test

Discussions

The results obtained after applying the eight-week functional training program confirm the hypothesis that this type of training leads to a significant improvement in explosive strength and vertical jump in adolescent basketball athletes. The increasing mean values for all tests (CMJ, RJ5, SJ), as well as the extremely low p-values ($p < 0.001$), indicate that the observed differences are not random, but the direct result of the intervention.

An important aspect highlighted is the effect size (Cohen's $d > 1.0$), which demonstrates not only statistical significance but also major practical impact on sports performance. These findings are consistent with the literature, which emphasizes that functional and plyometric training contribute to enhancing neuromuscular capacities and developing explosive strength (Faigenbaum, A.D. et al., 2009; Myer et al., 2011).

The RJ5 test results suggest a clear improvement in reactive capacity, shown by the increase in repeated jump height and reduction in contact times. This is supported by studies indicating that the Reactive Strength Index (RSI) is a key indicator for performance in sports requiring repeated jumps and changes of direction (Read & Lloyd, 2014; Wilkerson & Giles, 2011).

Furthermore, the coefficient of variation values (CV% between 14 and 21%) indicate moderate variability, typical of adolescents undergoing biological and neuromuscular development (Lloyd et al., 2015). The more pronounced progress in boys in RJ5 can be explained by higher muscle mass, while the better results in girls in SJ indicate superior neuromuscular recruitment capacity in concentric tasks, a finding supported by previous research (Ford, K.R., Myer, G.D., & Hewett, T.E., 2003).

The literature suggests that introducing functional and plyometric training programs at early ages not only stimulates performance but also contributes to injury prevention by strengthening neuromuscular control and joint stability (Granacher et al., 2016; Behm et al., 2008; Teris, S., & Enoiu, S.R., 2021; Ștefan, & Sandu, 2021). The results obtained in this study support this perspective and demonstrate that a structured and progressive program can be successfully implemented with adolescent athletes.

Overall, the data confirm the working hypothesis and align with current trends in the literature, which state that functional training is an effective method for optimizing sports performance and vertical jump in basketball (Zemkova & Hamar, 2010; Winter & Fowker, 2009). This study, although providing relevant and significant results for optimizing explosive strength in adolescent athletes through functional training, presents a number of limitations that must be considered when interpreting and generalizing the conclusions:

Lack of a control group. The pre–post test design without a control group reduces internal validity, since the influence of other external factors (biological growth, ongoing training, etc.) on the observed progress cannot be completely excluded.

Small and homogeneous sample. All participants came from the same sports club, which limits the generalizability of the results to other athletic populations (other clubs, performance levels, or different sports).

Relatively short intervention period. The eight-week period is suitable for observing initial changes but does not provide information on the sustainability of progress in the long term or on the potential transfer to actual gameplay.

The results of this study have several direct implications for coaches, strength and conditioning specialists, and youth athlete development experts:

Integration of functional training in adolescent preparation. The data support the use of functional and plyometric exercises in young athletes' training cycles as an effective method to develop explosive strength without significant risks.

Progressive structuring of exercises. The applied program, divided into four phases (adaptation, strength development, plyometrics, integration into play), can serve as a model for planning microcycles, promoting neuromuscular adaptation and preventing overtraining.

Objective monitoring of progress. The use of systems such as Optojump allows for rigorous and standardized evaluation of vertical jump, providing coaches with a precise tool for individualized adjustment of training programs.

4. Conclusions

The eight-week functional training program produced statistically significant improvements ($p < 0.001$) in all three explosive strength assessment tests (CMJ, RJ5, SJ), in both boys and girls.

The high effect size values (Cohen's $d > 1.0$) indicate not only the statistical significance of the progress but also a major practical impact on the development of vertical jump in adolescent basketball athletes.

The increase recorded in the RJ5 test confirms the improvement of reactive capacity and the use of the stretch–shortening cycle, while the progress in the SJ test suggests the development of pure concentric strength, particularly in girls.

The coefficient of variation (CV%) showed moderate variability (14–21%), characteristic of the pubertal age, but with a tendency toward performance homogenization after the intervention, especially in boys.

Overall, the results confirm the research hypothesis, demonstrating that a structured functional training program is an effective and safe method for optimizing explosive strength and vertical jump performance in the preparation of adolescent basketball athletes.

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