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Original Article

The Effect of Plyometric Training on Long Jump Performance in Junior Athletes

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Abstract

The purpose of the study was to evaluate the effects of an 8-week plyometric training program on long jump performance with run-up in junior athletes practicing athletics, aged between 14 and 16 years. A total of 38 participants took part in the study, divided into a control group and an experimental group. The experimental group performed plyometric exercises twice per week, in addition to regular training. Performance was assessed before and after the intervention. The results showed an average performance increase of 15.0 cm in the experimental group, which was statistically significant ($p < 0.001$), compared with an increase of 1.7 cm in the control group. The effect size was very large (Cohen's $d = 2.17$). The findings confirm the effectiveness of plyometric training in improving long jump performance in junior athletes.

1. Introduction

The long jump is one of the fundamental events in athletics, requiring an integrated contribution of explosive strength, neuromuscular coordination, and movement control during the run-up, take-off, flight, and landing phases. Performance in this event largely depends on the athlete's ability to produce force in a very short time, especially at the moment of take-off from the ground, where the efficiency of lower-limb explosive strength plays a decisive role (Bosco, Luhtanen & Komi, 1983; Komi, 2000). During adolescence, the development of neuromuscular qualities has high potential due to accelerated processes of biological maturation and functional adaptation. The scientific literature highlights that the age range of 14 to 16 years is favorable for optimizing explosive strength, provided that specific, progressive training stimuli adapted to the children's level of development are applied (Malina, Bouchard & Bar-Or, 2004; Lloyd et al., 2015). In the absence of such stimuli, performance improvement may be limited, even within the context

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of regular training.

Plyometric training is recognized as one of the most effective methods for developing explosive strength, as it is based on the exploitation of the stretch–shortening cycle. This biomechanical mechanism allows the storage of elastic energy during the eccentric phase and its reuse during the concentric phase, leading to increased force and power output (Komi, 2000). Numerous studies have demonstrated the positive effects of plyometric training on jumping performance in young athletes, both in vertical and horizontal events (Markovic, 2007; Ramirez-Campillo, Andrade & Izquierdo, 2015). In athletics, horizontal jumping events require not only a high level of explosive strength but also precise neuromuscular control, which enables the efficient transfer of run-up speed into the vertical component of take-off. For this reason, general strength training may be insufficient if it is not complemented by plyometric-specific and technically oriented exercises (Meylan & Malatesta, 2009). Beyond strictly physiological aspects, the training of young athletes must be conducted within a clear methodological and ethical framework. Recent studies emphasize the importance of respecting ethical and professional deontological norms in physical education and sport activities, especially when working with children and adolescents (Teris & Enoiu, 2023; Teris & Alecu, 2025). This framework contributes to creating a safe environment that supports harmonious development and prevents injuries or overtraining.

Research in the field of youth athlete development shows that well-structured training models can produce significant effects on performance, even at young ages, when they are adapted to the level of development and specific objectives (Teris, Lakotos & Koronas, 2024). Although this type of approach is frequently studied in team sports, its systematic application in youth athletics events remains insufficiently documented.

At the same time, the literature highlights the importance of an interdisciplinary approach in the study of performance in junior athletes, where factors such as cognitive development, attentional control, and motor learning capacity can influence sports outcomes (Ciprian, Sandu & Stefan, 2023). This perspective supports the need for training programs that address not only the physical component but also the overall adaptation of the young athlete.

In this context, studies on the effectiveness of plyometric training in children practicing athletics are necessary to provide a scientific basis for training programs. In addition, comparative analysis between regular training and training supplemented with plyometric exercises provides relevant information for optimizing the sports training process (Onea & Balint, 2017; Onea, Balint & Pascu, 2017, Zemková, & Hamar, 2010).

Considering the importance of explosive strength in the long jump, the high developmental potential during adolescence, and the demonstrated effectiveness of plyometric exercises, the present study aims to investigate the effects of an 8-week plyometric training program on long jump performance with run-up in junior athletes aged between 14 and 16 years, compared with regular training.

2. Material and Methods

The purpose of this study was to evaluate the effects of a plyometric training program conducted over a period of 8 weeks on long jump performance with run-up in children practicing athletics. The working hypothesis was that the systematic introduction of plyometric exercises leads to significant improvements in long jump distance compared with regular training.

The study included 38 junior athletes practicing athletics, aged between 14 and 16 years. The sample consisted of 20 boys and 18 girls, registered with sports clubs and engaged in regular training activity of at least three sessions per week. Sporting experience ranged from 0.5 to 5 years. The participants reported no muscular or joint injuries during the previous 6 months. Participation was based on informed consent obtained from parents or legal guardians, in accordance with ethical principles regarding research involving minors.

An experimental pretest–posttest design with a control group was used. The participants were assigned to two equal groups according to age and initial performance level. The control group included 19 subjects and followed the standard athletics training program. The experimental group included 19 subjects and followed the same standard program, supplemented with a plyometric training protocol. Initial testing was performed before the start of the intervention, and final testing after 8 weeks.

The plyometric program presented in Table 1 was conducted over 8 weeks, with a frequency of two sessions per week, integrated into the structure of regular training. The duration of each session was approximately 20 to 25 minutes. A minimum interval of 48 hours was maintained between sessions. The program was structured progressively, from exercises of moderate intensity to exercises with a more pronounced explosive character.

During the first two weeks, neuromuscular adaptation exercises were used, such as stationary jumps, forward jumps with both legs, and coordination exercises. In weeks 3 and 4, the focus was on developing explosive strength through single-leg jumps, alternating jumps, and jumps over low obstacles. In weeks 5 and 6, reactive plyometric exercises were introduced, such as drop jumps from 30 to 40 cm and consecutive forward jumps. In the final two weeks, the emphasis was on transfer to the specific event through short run-up jumps and combinations of running and take-off.

Performance evaluation was carried out using the long jump with run-up. Tests were conducted on a standard athletics track under the same conditions for all participants. Assessments were performed at the same time of day. The warm-up was standardized and lasted 15 minutes. Each participant performed three valid attempts, with the best performance being recorded. The distance was measured in centimeters from the take-off line to the nearest point of contact with the sand, using a certified measuring tape. Anthropometric data, including height, body mass, and sporting experience, were also recorded to characterize the sample.

Table 1. *Plyometric intervention program, 8 weeks*

Phase	Weeks	Main Objective	Recommended plyometric exercises	Sets × Repetitions
Neuromuscular adaptation	1–2	Learning technique, preparation of the locomotor system	Stationary jumps with both legs. Short-distance forward jumps. Alternating stationary jumps. Skipping running drills. |	3×10. 3×8. 3×10. 3×20 m
Development of explosive strength	3–4	Increasing lower-limb explosive strength	Single-leg forward jumps. Jumps over low obstacles, 20–30 cm. Alternating forward jumps.	3×8 per leg 4×10. 3×20 m
Reactive plyometrics	5–6	Activation of the stretch–shortening cycle	Drop jumps from 30–40 cm. Consecutive forward jumps. Single-leg jumps with rapid ground contact.	4×8. 3×10. 3×8 per leg
Event-specific integration	7–8	Transfer to the long jump with run-up	Short run-up + take-off. Long jump with controlled run-up. Running–take-off–landing combinations.	4×6. 4×4. 3×6

The data were compiled in an electronic table and checked for accuracy. The mean, standard deviation, and minimum and maximum values were calculated for each analyzed variable. Differences between initial and final testing were analyzed within each group, as well as comparatively between the control group and the experimental group.

The threshold for statistical significance was set at $p < 0.05$. Statistical analysis was performed using standard statistical software commonly used in research in the field of physical education and sport.

3. Results and Discussions

The analysis of the results aimed to highlight the effects of the plyometric training program on long jump performance with run-up in junior athletes aged between 14 and 16 years.

Performance was evaluated by comparing the values obtained at initial testing and final testing, both within each group and between the control group and the experimental group.

Table 2 presents the descriptive statistical values for long jump performance, expressed in centimeters, for the two groups at initial and final testing.

Table 2. *Descriptive statistics of long jump performance (cm)*

Group	Testing	Mean (X)	SD	Min	Max	CV%
Control	Initial	421.6	24.8	378.1	467.5	5.88
Control	Final	423.3	25.6	375.8	460.5	6.05
Experimental	Initial	419.6	30.2	330.0	474.8	7.20
Experimental	Final	434.6	31.1	331.7	492.1	7.15

X = arithmetic mean, SD = standard deviation, Min = minimum value, Max = maximum value, CV% = coefficient of variation.

The initial mean values indicate a comparable level of performance between the two groups, with a small difference between means. The coefficient of variation shows moderate variability of the results, which is specific to the analyzed age and to individual differences in biological development and sporting experience.

At final testing, the experimental group shows a clear increase in mean performance, while the control group records a minimal change with no practical relevance. The CV% values remain relatively constant, suggesting that the improvement was relatively uniform within the experimental group. To evaluate the changes that occurred during the intervention period, the difference between initial and final testing was analyzed for each participant. Table 3 presents the results of the pre–post difference analysis within each group.

Table 3. *Pre–post differences within groups*

Group	ΔX (cm)	SD	t	p
Control	+1.7	5.6	1.32	0.203
Experimental	+15.0	6.9	9.41	< 0.001

* ΔX = mean difference between final and initial testing, SD = standard deviation of the differences, t = t-test value for paired samples, p = level of statistical significance.

In the control group, the mean improvement was 1.7 cm. The t-test value and the level of significance indicate that this difference is not statistically significant. This result suggests that regular training did not produce relevant adaptations in explosive strength required to improve long jump performance.

In the experimental group, the mean improvement was 15.0 cm. The difference is statistically significant, with a very high level of probability. This increase indicates a clear effect of the plyometric program on take-off ability and on the efficient use of explosive strength during the take-off phase.

To highlight the actual impact of the intervention, a comparison was made between the mean progress differences of the two groups. The results are presented in Table 4.

Table 4. *Comparison of progress between groups*

Group	ΔX (cm)	SD	t	p
Control	1.7	5.6		
Experimental	15.0	6.9	7.02	< 0.001

* ΔX = mean recorded progress, SD = standard deviation, t = t-test value for independent samples, p = level of statistical significance.

The difference between the progress of the two groups is statistically significant. This finding confirms that the improvements observed in the experimental group cannot be explained by external factors such as biological growth or natural adaptation to effort, but represent the direct effect of the applied plyometric training program. To assess the practical relevance of the results, the effect size was calculated using Cohen's d. The results are presented in Table 5.

Table 5. *Effect size for performance progress*

Group	Cohen's d	Interpretation
Control	0.30	small effect
Experimental	2.17	very large effect

* Cohen's d = effect size indicator, interpretation according to standard thresholds: small effect ($d \approx 0.2$), medium effect ($d \approx 0.5$), large effect ($d \geq 0.8$).

The value of Cohen's d for the experimental group indicates a very large effect of the intervention, with major practical impact on sports performance. In the control group, the effect size is small, confirming the absence of relevant changes.

The obtained results demonstrate the effectiveness of the plyometric training program in improving long jump performance in junior athletes aged between 14 and 16 years. The mean increase of 15 cm recorded in the experimental group represents a significant improvement from a sporting perspective, with the potential to directly influence competitive outcomes. The stability of the coefficient of variation suggests that the intervention did not benefit only participants with a high initial level, but produced generalized adaptations at the group level. The observed variability reflects individual differences in development, without affecting the overall direction of progress.

The clear differences between the two groups confirm the working hypothesis and support the integration of plyometric exercises into training programs for children practicing athletics, as an effective method for optimizing explosive strength and long jump performance.

Discussions

The results obtained in this study confirm the effectiveness of the plyometric training program applied over an 8-week period in improving long jump performance with run-up in junior athletes aged between 14 and 16 years. The significant performance increase recorded in the experimental group, compared with the minimal changes observed in the control group, supports the hypothesis that plyometric exercises represent a specific and effective stimulus for the development of lower-limb explosive strength. The mean improvement of approximately 15 cm observed in the experimental group has high practical relevance for the long jump event. The scientific literature shows that even smaller improvements can significantly influence competitive rankings at the youth level (Bosco et al., 1983). This aspect is explained by the decisive role of explosive strength and take-off efficiency in achieving an optimal trajectory during the take-off phase.

The results are consistent with studies highlighting the positive effects of plyometric training on jumping performance in young athletes (Markovic, 2007; Ramirez-Campillo et al., 2015). These studies emphasize that plyometric exercises stimulate rapid neuromuscular adaptations by improving intermuscular coordination and increasing the rate of force development. In the context of the present study, these adaptations are reflected in the participants' ability to produce a more effective take-off during the jump. A central element explaining the observed progress is the optimization of the stretch–shortening cycle. According to Komi (2000), efficient use of this mechanism allows the storage and reuse of elastic energy, increasing force production during the concentric phase. The plyometric exercises included in the intervention program were specifically designed to stimulate this mechanism, particularly through reactive jumps and drop jumps, which justifies the magnitude of the recorded improvement.

The lack of significant changes in the control group suggests that standard athletics training, in the absence of an additional specific stimulus, is not sufficient to produce relevant explosive strength adaptations over a relatively short period. This finding is supported by the conclusions of Lloyd et al. (2015), who show that the development of neuromuscular qualities in adolescents requires targeted and well-structured stimuli adapted to age-related characteristics. The variability of results within the experimental group can be explained by individual differences in biological maturation, sporting experience, and initial performance level. Studies on long-term athlete development indicate that adolescence is characterized by different rates of adaptation, even within the same chronological age group (Malina et al., 2004). Nevertheless, the overall direction of progress was positive for most participants, indicating the general effectiveness of the intervention.

The very large effect size observed in the experimental group confirms not only the statistical significance of the results but also their practical impact. According to Cohen (1988), high effect size values indicate interventions with real applied relevance. In the context of youth athletics, this aspect is essential, as the primary objective of training is not merely to obtain statistical differences but to improve sports performance in a functional manner that can be transferred to competition.

The findings of the present study are also in agreement with research that has analyzed the effects of plyometric training on horizontal jumping events. For example, Meylan and Malatesta (2009) reported significant improvements in long jump performance and explosive strength tests following similar programs applied to young athletes. These data support the idea that plyometrics represent an effective method for developing capacities specific to jumping events.

Another important aspect is the safety of program implementation. No injuries were reported during the intervention period, which is consistent with the conclusions of Faigenbaum et al. (2009), who showed that plyometric training is safe for children and adolescents when structured progressively and adapted to the level of preparation. This is relevant for coaches, as it demonstrates that such programs can be integrated into regular training without increasing the risk of injury.

From a methodological perspective, the use of a control group design strengthens the validity of the conclusions. The significant differences between groups indicate that the observed progress cannot be attributed solely to biological growth or general adaptation to effort. This aspect is essential in studies conducted on young populations, where maturation can influence performance (Malina et al., 2004).

Overall, the results support the systematic integration of plyometric exercises into training programs for children practicing athletics, especially for events that require explosive strength and intersegmental coordination, such as the long jump.

4. Conclusions

The results obtained in this study show that the application of a plyometric training program conducted over an 8-week period leads to significant improvements in long jump performance with run-up in junior athletes aged between 14 and 16 years.

The mean performance increase recorded in the experimental group confirms the effectiveness of plyometric exercises in developing lower-limb explosive strength and in optimizing the take-off phase, which is an essential element for achieving an efficient trajectory in the long jump. The absence of significant changes in the control group indicates that regular training, in the absence of a specific plyometric stimulus, does not produce relevant short-term performance adaptations in this age category.

The very large effect size observed in the experimental group highlights the practical impact of the intervention, demonstrating that the applied program has not only statistical value but also direct relevance for sports training and competitive performance.

The progressive structuring of the exercises, adapted to the children’s level of development, allowed positive results to be achieved without the occurrence of injuries, which supports the applicability and safety of plyometric training in the preparation of young athletes.

The obtained data support the systematic integration of plyometric exercises into training programs for children practicing athletics, especially for jumping events, as an effective method for developing explosive strength and improving specific performance.

The results of this study may serve as a methodological reference for coaches and physical education teachers in planning training programs aimed at developing neuromuscular qualities at the youth level.

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