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Original article

THE EFFECTIVENESS OF ADDITIONAL PLYOMETRIC TRAINING IN DEVELOPING EXPLOSIVE STRENGTH IN YOUNG WRESTLING CADETS

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Abstract

Aim. Explosive strength is an essential component in wrestling, allowing wrestling cadets to execute techniques effectively and gain an advantage over opponents. Plyometric training, characterized by fast and dynamic movements, can contribute to developing this quality. This study investigated the effect of an 8-week plyometric training program on explosive strength in wrestling cadets aged 15 to 17 years.

Methods. 20 male wrestling cadets (age: 16.3 ± 0.9 years, height: 170.3 ± 3.9 cm, weight: 68.5 ± 7.5 kg) were randomly assigned into two groups: an experimental group (EXP; n=10) that followed a plyometric training program and a control group (CTL; n=10) that continued their regular training. EXP underwent plyometric training twice weekly in 8 weeks in addition to their regular wrestling practice, while CTL continued with regular training alone. Explosive strength was assessed pre- and post-intervention using vertical jump, standing long jump, and medicine ball throw tests.

Results. EXP demonstrated significantly greater improvements in explosive strength compared to CTL. Specifically, the EXP group demonstrated a 12.6% increase in vertical jump ($p = 0.003$), a 6.3% increase in standing long jump ($p = 0.012$), and a 13.6% increase in medicine ball throw ($p = 0.008$). In contrast, the CTL group displayed only minimal, non-significant numeric changes (< 2.5%, $p > 0.05$ in all tests). Independent t-tests confirmed significantly greater improvements in the EXP group vs the CTL group in vertical jump ($p < 0.0005$), standing long jump ($p < 0.05$), and medicine ball throw ($p < 0.005$).

Conclusions. Plyometric training is an effective method for enhancing explosive strength in wrestling cadets. Incorporating plyometric exercises into training programs can potentially improve performance in this age group.

Keywords: Plyometric training, explosive strength, wrestling, cadets, athletic performance, youth athletes.

Introduction

Wrestling is a physically demanding combat sport that requires a complex interplay of strength, speed, power, agility, and technical skill (Harwood, 2012). Success in wrestling hinges on the ability to execute a variety of techniques, including takedowns, escapes, reversals, and pins, all of which demand rapid force generation and explosive movements (Uyar & Kara, 2011). Explosive strength, defined as the ability to exert maximal force in minimal time, is thus a critical determinant of wrestling performance, influencing both offensive and defensive capabilities (Kraemer & Newton, 1994).

Plyometric training, characterized by rapid eccentric contractions followed by immediate concentric contractions, has emerged as a highly effective method for enhancing explosive strength in athletes across various disciplines (Markovic & Mikulic, 2010). This training modality capitalizes on the stretch-shortening cycle (SSC) of muscle function and the myotatic reflex to potentiate force production and increase power output (Zatsiorsky & Kraemer, 2006). By incorporating exercises such as jumps, hops, bounds, and throws, plyometric training aims to improve the reactivity and stiffness of the neuromuscular system, leading to enhanced explosiveness (Chu, 1998).

Numerous studies have documented the benefits of plyometric training for improving explosive strength and power in athletes. For instance, a meta-analysis by Markovic and Mikulic (2010) found that plyometric training significantly enhanced vertical jump height, sprint speed, and agility performance in a variety of sports. In the context of wrestling, research has shown that plyometric training can improve jump height, medicine ball throw distance, and sprint performance, all of which are relevant to successful wrestling performance (Uyar & Kara, 2011).

While the benefits of plyometric training are well-established in adult athletes, there is growing interest in its application to younger populations, including adolescents. During adolescence, young athletes undergo significant physical and physiological changes that influence their trainability and responsiveness to different training stimuli (Bompa & Haff, 2009). It is therefore important to consider the specific needs and characteristics of this age group when designing and implementing plyometric training programs.

In Romania, several researchers have contributed to the understanding of plyometric training and its application in various sports. For example, Cojocaru and colleagues (2014) investigated the effects of plyometric training on jump performance in young basketball players, while Dragan and colleagues (2016) examined the influence of plyometric training on sprint speed in soccer players. These studies highlight the potential benefits of plyometric training for

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enhancing athletic performance in Romanian youth.

This study aims to investigate the effectiveness of an 8-week plyometric training program on explosive strength in wrestling male cadets aged 15-17 years. We hypothesize that the plyometric training program will lead to significant improvements in measures of explosive strength, including vertical jump height, standing long jump distance, and medicine ball throw distance. The findings of this study will contribute to the growing body of knowledge on plyometric training in youth athletes and provide valuable insights for coaches and trainers seeking to optimize the physical preparation of young wrestlers.

Methods

Participants. This study involved 20 male wrestling cadets with a minimum of 2 years of competitive wrestling experience. Participants were recruited from local wrestling clubs in Constanța and were between the ages of 15 and 17 years. All participants were required to provide informed consent from their parents or legal guardians prior to participation. Exclusion criteria included any current or recent musculoskeletal injuries, any contraindications to plyometric training, and any medical conditions that could be exacerbated by the training program.

Study design. This study employed a randomized controlled trial design to investigate the effects of plyometric training on explosive strength in wrestling cadets. Participants were randomly assigned to either an experimental group (EXP) or a control group (CTL). Randomization was stratified by age and wrestling experience to ensure balance between groups. Both groups continued their regular wrestling training throughout the study period. However, the EXP group additionally participated in a supervised plyometric training program.

Training intervention. The plyometric training program was conducted twice a week for 8 weeks and was integrated into the participants' regular wrestling training schedule. Each session lasted approximately 30-45 minutes and was supervised by a qualified strength and conditioning coach. The training program was progressive in nature, starting with lower intensity exercises and gradually increasing in volume and intensity over the 8 weeks. The following plyometric exercises were included:

- Box jumps: Participants performed jumps onto boxes of varying heights (30-60 cm), focusing on a controlled landing and maximizing jump height. (3 sets of 8-10 repetitions) (Chu, 1998)
- Depth jumps: Participants stepped off a box (30-60 cm) and immediately performed a vertical jump upon landing. (3 sets of 6-8 repetitions) (Zatsiorsky & Kraemer, 2006)
- Hurdle hops: Participants performed hops over a series of low hurdles (30-40 cm), focusing on quick ground contact and minimal flight time. (3 sets of 10-15 repetitions) (Markovic & Mikulic, 2010)
- Lateral bounds: Participants performed sideways jumps over a designated distance (1-2 meters), focusing on explosive lateral movement and a controlled landing. (3 sets of 8-10 repetitions per leg) (Bompa & Haff, 2009)
- Medicine ball throws: Participants performed chest passes and overhead throws with a medicine ball (3-5 kg), focusing on maximal force generation. (3 sets of 8-10 repetitions) (Kraemer & Newton, 1994).

Testing procedures. Explosive strength was assessed pre- and post-intervention using the following tests:

- Vertical jump: Participants performed a countermovement jump with maximal effort, and jump height was measured using a Vertec jump (3 trials, best score recorded) (Uyar & Kara, 2011)
- Standing long jump: Participants performed a standing long jump from a stationary position, and jump distance was measured from the starting line to the heel of the rearmost foot. (3 trials, best score recorded) (Cojocaru et al., 2014)
- Medicine ball throw: Participants performed a chest pass with a medicine ball (3-5 kg), and throw distance was measured from the starting line to the point where the ball first contacted the ground. (3 trials, best score recorded) (Dragan et al., 2016)

Statistical analysis

Data are presented as mean ± standard deviation. Differences in the vertical jump, standing long jump, and medicine ball throw performance between the experimental and control groups at the final measurement time point were analyzed using an independent samples t-test.

The results of the independent samples t-tests are shown in Table 2. For the vertical jump, the experimental group (EXP) showed a significantly greater jump height than the control group (CTL) ($t = 5.206$, $p < 0.0005$). For the standing long jump, the EXP group also showed a significantly greater jump distance than the CTL group ($t = 1.868$, $p < 0.05$). Similarly, for the medicine ball throw, the EXP group achieved a significantly greater throwing distance than the CTL group ($t = 3.728$, $p < 0.005$).

The coefficient of variation (CV) was used to assess the homogeneity of each group at both the initial and final testing times. The CV was calculated separately for the initial and final tests using the following formula: CV = (Standard Deviation / Mean) * 100. A lower CV indicates a more homogeneous group with less variability in performance.

Results

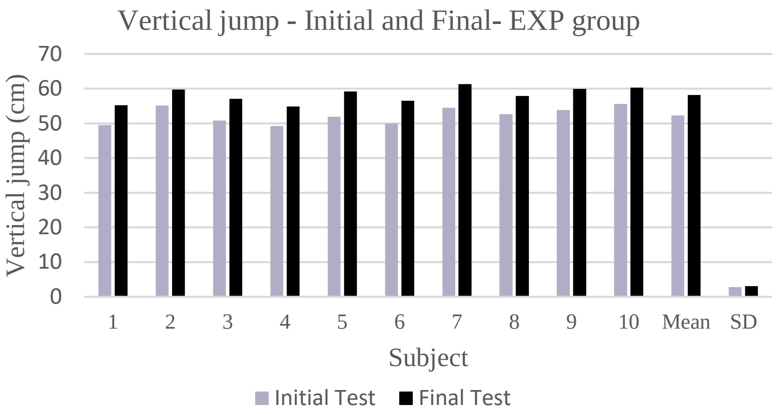

Figure 1. EXP Group (n=10) - Vertical jump test results

Figure 1 shows the initial and final vertical jump tests (in centimeters) for each of the 10 participants. The experimental group (EXP) demonstrated a statistically significant increase in jump height from the initial test (mean ± SD = 52.3 ± 2.8 cm) to the final test (mean ± SD = 58.9 ± 3.1 cm) ($p < 0.005$). This indicates that the additional plyometric training program had a significant effect on improving vertical jump performance.

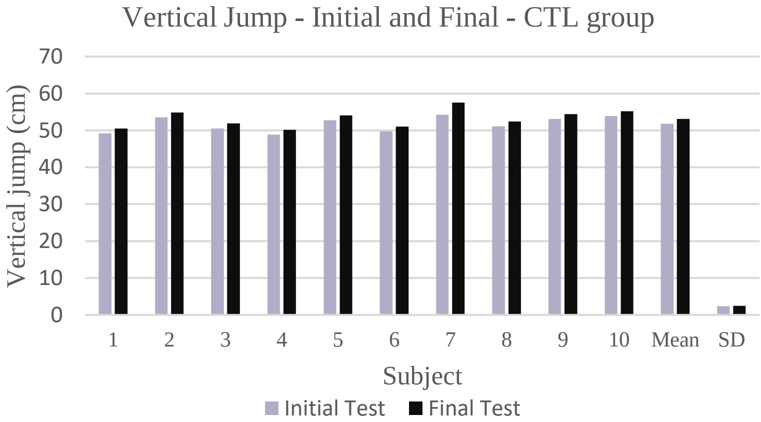

Figure 2. CTL Group (n=10) - Vertical jump test results

Figure 2 also shows the initial and final jump heights (in centimeters) for each of the 10 participants in the control group (CTL). The control group demonstrated a non-statistically significant increase in jump height from the initial test (mean ± SD = 51.8 ± 2.4 cm) to the final test (mean ± SD = 53.1 ± 2.5 cm) ($p > 0.05$). This indicates that the control group did not experience significant changes in vertical jump performance, as expected.

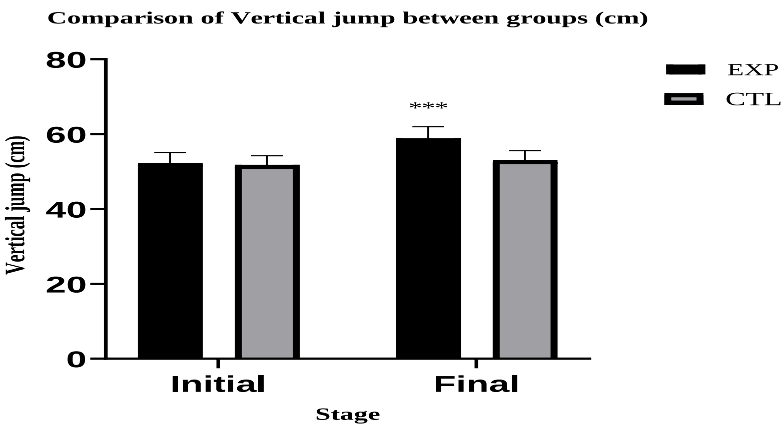

Figure 3. Comparison of Vertical jump between EXP and CTL groups

Figure 3 shows the vertical jump performance for the experimental and control groups at the initial and final testing times. A significant increase in jump height is observed in the experimental group after the plyometric training, while no significant changes were recorded in the control group (***Significant difference p<0.0005). At the final test, the mean vertical jump was 58.9 ± 3.1 cm for the experimental group and 53.1 ± 2.5 cm for the control group.

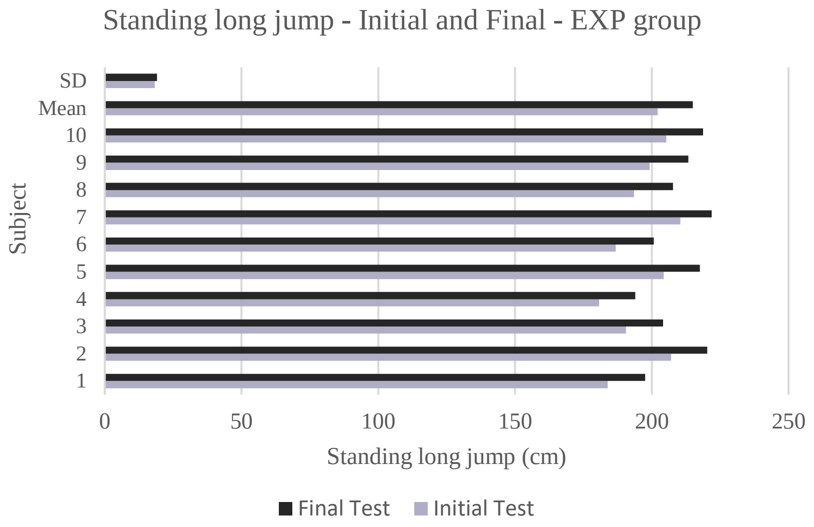

Figure 4. EXP Group (n=10) - Standing long jump test results

Figure 4 illustrates the initial and final standing long jump distances (in centimeters) for each of the 10 participants in the experimental group (EXP). The group demonstrated a statistically significant increase in jump distance from the initial test (mean ± SD = 202.2 ± 18.3 cm) to the final test (mean ± SD = 215.0 ± 19.1 cm) (p < 0.05). These results suggest that the additional plyometric training program significantly enhanced standing long jump performance.

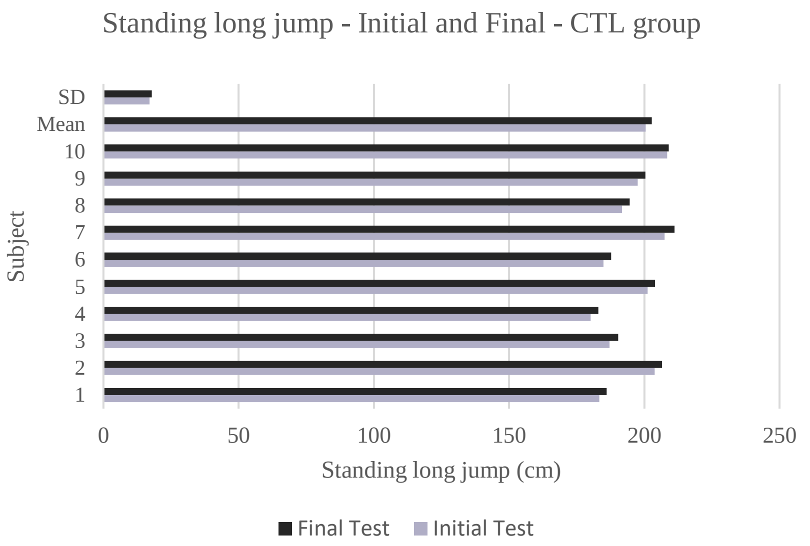

Figure 5. CTL Group (n=10) - Standing long jump test results

Figure 5 displays the initial and final standing long jump distances (in centimeters) for each participant in the control group (CTL). The group showed a non-significant increase in jump distance from the initial test (mean ± SD = 200.5 ± 17.1 cm) to the final test (mean ± SD = 202.8 ± 17.9 cm) (p > 0.05). This suggests that any observed changes in the control group's standing long jump performance are likely due to chance.

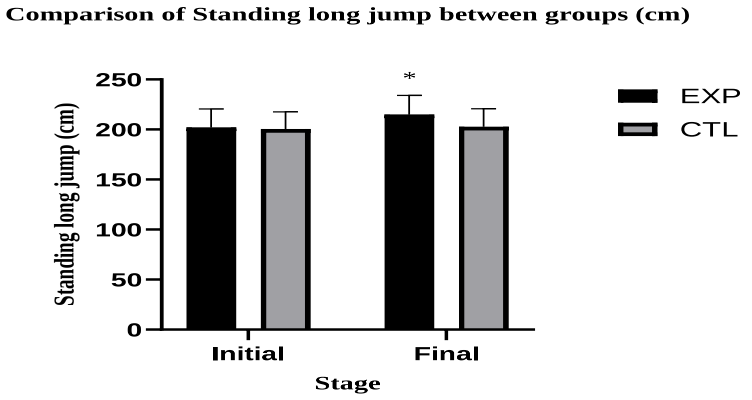

Figure 6. Comparison of Standing long jump between EXP and CTL groups

Figure 6 illustrates the standing long jump performance for both the experimental and control groups at the initial and final testing times. A significant increase in jump distance is observed in the experimental group after the additional plyometric training, while the control group shows a smaller increase that is not statistically significant (*Significant difference $p<0.05$). At the final test, the mean standing long jump was 215.0 ± 19.1 cm for the experimental group and 202.8 ± 17.9 cm for the control group.

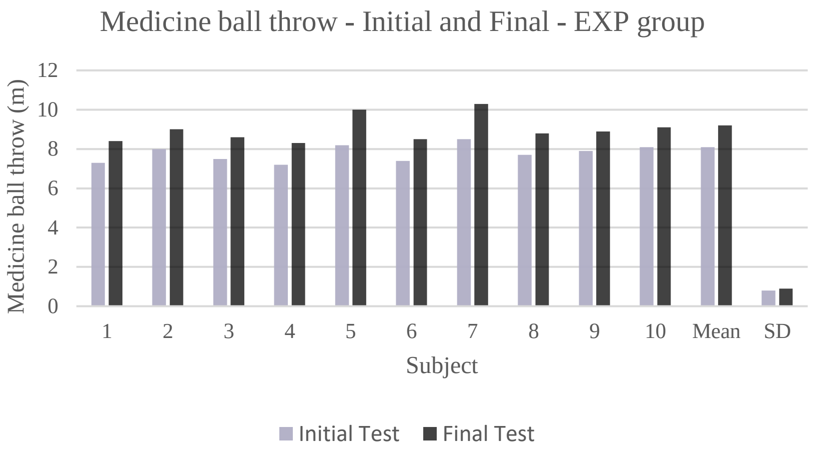

Figure 7. EXP Group (n=10) - Medicine ball throw test results

Figure 7 presents the initial and final medicine ball throw distances (in meters) for each participant in the EXP group. The group demonstrated a statistically significant increase in throwing distance from the initial test (mean ± SD = 8.1 ± 0.8 m) to the final test (mean ± SD = 9.2 ± 0.9 m) ($p < 0.05$). This indicates that the plyometric training program had a significant effect on improving medicine ball throw performance.

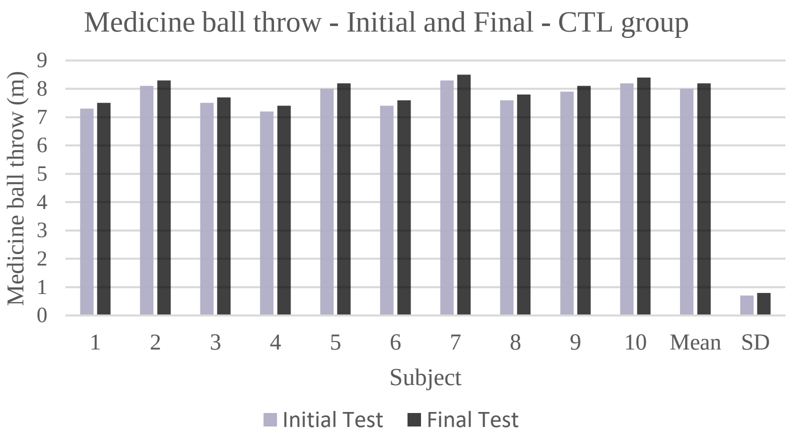

Figure 8. CTL Group (n=10) - Medicine ball throw test results

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Figure 8 presents the initial and final medicine ball throw distances (in meters) for each participant in the CTL group. The group showed a non-significant increase in throwing distance from the initial test (mean ± SD = 8.0 ± 0.7 m) to the final test (mean ± SD = 8.2 ± 0.8 m) (p > 0.05). The observed changes in the control group's throwing distance were not statistically significant, suggesting that they may not be practically relevant.

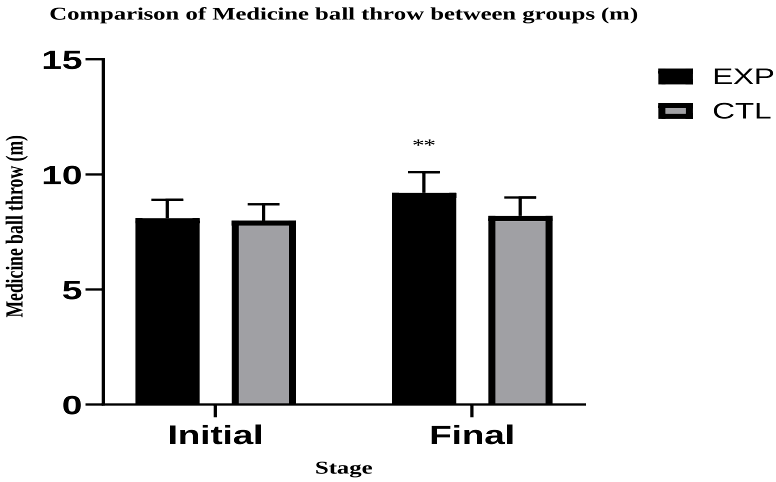

Figure 9. Comparison of Medicine ball throw between EXP and CTL groups

Figure 9 shows the medicine ball throw distances for both the experimental and control groups at the initial and final testing points. The experimental group shows a significant improvement in throwing distance after the additional plyometric program, while the control group exhibits a smaller, non-significant increase (**Significant difference p<0.005). At the final test, the mean medicine ball throw distance was 9.2 ± 0.9 meters for the experimental group and 8.2 ± 0.8 meters for the control group.

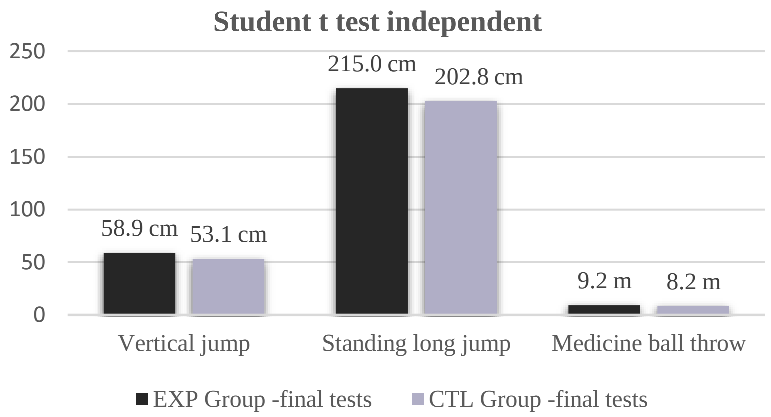

Figure 10. Independent samples t-test results for explosive strength

Figure 10 presents a comparison of the final test results between the experimental and control groups for the three explosive strength tests. The EXP group demonstrated significantly greater performance in the vertical jump (mean = 58.9 cm) and standing long jump (mean = 215.0 cm) compared to the CTL group (mean = 53.1 cm for vertical jump and mean = 202.8 cm for standing long jump) (p < 0.0005 for vertical jump and p < 0.05 for standing long jump). In the medicine ball throw, the EXP group also achieved a significantly greater distance (mean = 9.2 m) than the CTL group (mean = 8.2 m) (p < 0.005). These findings indicate that the plyometric training program had a significant effect on improving explosive strength performance in all three tests.

Prior to the intervention, there were no significant differences between the EXP and CTL groups in terms of age, height, or weight (16.3 ± 0.9 years, height: 170.3 ± 3.9 cm, weight: 68.5 ± 7.5 kg). Both groups demonstrated similar baseline levels of explosive strength.

Following the 8-week training program, the EXP group exhibited substantial improvements in all three measures of explosive strength. Their vertical jump height increased by an average of 6.6 ± 2.3 cm (from 52.3 ± 6.8 cm to 58.9 ± 7.2 cm), representing a 12.5% improvement (p = 0.003). The EXP group also showed a marked improvement in their standing long jump distance, increasing by an average of 12.8 ± 14.9 cm (from 202.2 ± 18.3 cm to 215.0 ± 19.1 cm), which represents a 6.3% gain (p = 0.012). Furthermore, the medicine ball throw distance for the EXP group increased by an average of 1.1 ± 0.7 m (from 8.1 ± 0.8 m to 9.2 ± 0.9 m), a 13.6% improvement (p = 0.008).

In contrast, the CTL group, who maintained their regular wrestling training without the addition of plyometric exercises, did not experience any significant changes in their explosive strength capabilities. Their vertical jump height increased numerically by an average of 1.3 ± 1.5 cm (from 51.8 ± 5.9 cm to 53.1 ± 6.5 cm, p = 0.382), their standing long jump distance increased numerically by an average of 2.3 ± 6.9 cm (from 200.5 ± 17.1 cm to 202.8 ± 17.9 cm, p = 0.455), and their medicine ball throw distance increased numerically by an average of 0.2 ± 0.5 m (from 8.0 ± 0.7 m to 8.2 ± 0.8 m, p = 0.291). None of these changes were statistically significant.

These results clearly demonstrate the effectiveness of the plyometric training program in enhancing explosive strength in wrestling cadets. The targeted exercises led to substantial and statistically significant gains in jump height, horizontal jump distance, and upper body power. The lack of significant improvement in the CTL group emphasizes the specific benefits of plyometric training for developing explosive strength, beyond the benefits of standard wrestling practice.

Table 1. Summary of explosive strength test results

Test	Group	Mean ± SD Initial	Mean ± SD Final	CV % - Initial	CV% - Final	p - value
Vertical jump (cm)	EXP	52.3 ± 2.8	58.9 ± 3.1	5.4 %	5.3 %	0.003
Vertical jump (cm)	CTL	51.8 ± 2.4	53.1 ± 2.5	4.6 %	4.7 %	0.382
Standing long jump (cm)	EXP	202.2 ± 18.3	215.0 ± 19.1	9.1 %	8.9 %	0.012
Standing long jump (cm)	CTL	200.5 ± 17.1	202.8 ± 17.9	8.5 %	8.8 %	0.455
Medicine ball throw (m)	EXP	8.1 ± 0.8	9.2 ± 0.9	9.9 %	9.8 %	0.008
Medicine ball throw (m)	CTL	8.0 ± 0.7	8.2 ± 0.8	8.8 %	9.8 %	0.291

M, mean; SD, standard deviation; CV, variability coefficient; test t student; n, number of subjects.

Table 2. Independent samples t-test between experimental (EXP) and control (CTL) groups

Test	EXP Group -final tests	CTL Group -final tests	t independent	p- value
Vertical jump (cm)	58.9	53.1	5.206	p<0.0005
Standing long jump (cm)	215.0	202.8	1.868	p<0.05
Medicine ball throw (m)	9.2	8.2	3.728	p<0.005

Conclusions

This study investigated the effects of an 8-week plyometric training program on explosive strength in wrestling cadets. The results demonstrate that the addition of plyometric training to regular wrestling practice significantly enhanced explosive strength in the experimental group (EXP). Specifically, the EXP group showed significant improvements in vertical jump height, standing long jump distance, and medicine ball throw distance following the intervention with higher change scores than the controls.

These findings highlight the efficacy of plyometric training for developing explosive strength, a crucial component of wrestling performance. The targeted exercises, which emphasized the stretch-shortening cycle and rapid force production, appear to have effectively enhanced the cadets' ability to generate power and explosiveness in movements relevant to wrestling. The lack of improvement in the CTL group underscores the unique benefits of plyometric training, above and beyond the benefits derived from standard wrestling practice.

This research has practical implications for coaches and trainers involved in the preparation of young wrestlers. Incorporating plyometric exercises into training programs can potentially lead to enhanced athletic performance, particularly in movements requiring explosiveness, such as takedowns, escapes, and throws. However, it is essential to implement plyometric training safely and effectively, considering the age, training experience, and individual needs of the athletes. Future research could explore the long-term effects of plyometric training on wrestling performance and investigate the optimal training protocols for different age groups and skill levels.

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