Effect of A 4-Week Plyometric Training Program on Explosive Power in U-17 School Boys: A Study of Jumping Events

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Accepted:20.07.2026 Published:10.08.2026 Page No. 63 – 68 DOI: 10.5281/zenodo.21802450

Abstract— *The athletic performance of the jumping events is specifically dependent on the specific physical capacities of the athlete who can generate force quickly. The purpose of the study was to assess the effect of a structured four-week plyometric training program on the explosive power of under-17 school boys in jumping events. A sample of thirty (N = 30) male school boys of age group 15 to 17 years was randomly selected and equally divided into two groups: experimental group (n = 15) and control group (n = 15). The experimental group underwent a plyometric training intervention for four weeks (five days per week, 45 minutes per day), while the control group continued with their normal physical education activities. The Standing Broad Jump (SBJ) and Vertical Jump Test (VJT) were used to assess lower-body explosive power. Data were analyzed using Mean, Standard Deviation, and Analysis of Covariance (ANCOVA) at a 5% significance level. According to the ANCOVA analysis, the experimental group showed significantly better performance in the Standing Broad Jump (F = 28.24, p < 0.001) and Vertical Jump (F = 40.23, p < 0.001) than the control group after controlling for initial measurements. Research ends that four-week micro-cycle concentrated plyometric training is an effective and economical means to enhance lower body explosive power and athletic readiness of adolescent sports setup.*

Keywords – Plyometric Training, Explosive Power, Standing Broad Jump, Vertical Jump, ANCOVA, Under-17 School Boys.

I. INTRODUCTION

In today's world, sports performance is highly affected by scientific training methods that enhance one's physical and physiological capacity. Among the components of physical fitness, explosive power is of utmost importance in athletic events that require generating force in a short interval of time. In track and field jumping events like the long jump, high jump, and triple jump, an athlete's success greatly depends on their ability to exert maximum force in a short timeframe during the take-off. Those traditional routines aimed at improving endurance can be great for general fitness; however, in most cases, they are insufficient to create the fast-twitch neuromuscular adaptations required for explosive jumping events. The biological phase of growth and development is crucial during adolescence. Boys aged 15 to 17 undergo major physiological changes, marked by increases in muscle mass, structural coordination, and neuromuscular recruitment capacity. The nervous system shows a high degree of flexibility during these years of maturation, so transfers can involve power or specialization. Plyometric training is one of the best ways to increase explosive power. According to Bompa, plyometric exercises employ the stretch-shortening cycle (SSC). As a result, the muscle moves rapidly into an eccentric action before following it with a powerful concentric action. Muscles and tendons can store and release elastic energy in this way. Heavy exposure to progressive plyometric exercises (such as bounding, depth jumps, and hurdle hops) improves coordination and the rate of force development (RFD) of motor units in athletes.

The Indian school sports system of regional areas focuses more on classical training that emphasizes a high running volume. It does not provide acute intensive neuromuscular conditioning. Further, it is difficult to execute longitudinal training blocks (continuously over 8-12 weeks without interruption) due to academic calendars, examinations, short sports camps, etc. Consequently, it is worth the investment and also cost-effective grassroots coaching to find out if a short-term concentrated 4-week plyometric training schedule can lead to significant improvements in lower body explosive power. This research was carried out by the author to fill in the gap in the literature on the study of changes in horizontal and vertical explosive power in a school sports setting.

II. RELATED WORK

Examining the historical and modern scientific literature can contextualize the impact of explosive ballistic interventions on adolescent school athletes. Many researchers have experimented with plyometric protocols to investigate the effects of duration, age groups, specific neuromuscular mechanisms, and performance.

The SSC is an important stimulus in the neuromuscular-skeletal base of plyometrics. Markovic and Mikulic (2010) offered a clarified meta-analytic decomposition with a more detailed breakdown of adaptations in motor unit synchronization and motor unit firing rate following lower-extremity plyometric exercises. It was suggested in the synthesis that eccentric loading, when performed rapidly, lowers the Golgi organ inhibitory activation thresholds. It also increases the agonist muscle co-activation and helps to deliver more power. Simultaneously, Markovic's (2007) study on vertical jump height across dozens of sports shows that plyometric training is useful for improving performance in the countermovement jump. Shown to be effective regardless of current training status.

Within modern training frameworks, the length of training periods in sport is still being debated. Conventional belief held that 8-12 week-long periods were necessary for visibly distinct physiological results. However, recent literature suggests shorter microcycles can be extremely effective at causing adaptations. A study conducted by Asadi (2013) that implemented a short-term, in-season plyometric program for young basketball players showed significant improvements in vertical jump height and explosive agility in a short period of time. In the same way, Meylan and Malatesta (2009) investigated the effect of incorporating a short plyometric block during a youth football practice season.

According to their findings, replacing sections of normal practice with a few sets of high-intensity concentric jumps and high-speed sprinting produced significant improvements in rapid directional changes and explosive takeoffs.

Structural testing has also been used to examine biomechanical adjustments from shorter plyometric. Kubo and coworkers (2007) studied changes in the mechanical properties of human tendon structures and found that a short plyometric program improved the stiffness of tendon structures (e.g., the Achilles tendon). The stiffness of a structure helps prevent deformation when it contacts the ground. This condition facilitates the rapid transfer of kinetic energy from muscles to bones. This plays an important role in maximizing take-off velocities during field track events. In addition, Burgess et al. (2016) showed that plyometric training increases overall musculotendinous stiffness. This demonstrates that even short training blocks can structurally adapt the muscle to become more responsive and to maximize jump performance.

Subjecting younger cohorts to explosive stimuli requires different physiological systems. Lloyd and Oliver (2012) created the Youth Physical

Development (YPD) model, noting that due to natural biological maturity impulses of the body, the adolescent nervous system is uniquely sensitive to stimuli to neuromuscular power. Between the ages of 15 to 17 years, the rapid development of coordination and muscle recruitment pathways provides an excellent opportunity for the safe introduction of progressive plyometric exercises such as bounding and depth jumps. Related research showed that a short, structured plyometric intervention proved to be a potent tool for enhancing explosive power within a limited academic time frame.

III. METHODOLOGY

A. Selection of Subjects

The current study's participants were thirty (30) male schoolboys aged between 15 and 17 years (under-17 category) drawn from regional high schools of District Bathinda. Participants were selected from the school's sports register to ensure true randomization and prevent bias. Each sports student was allocated a unique identification number. Using a table of random numbers generated by a computer, the samples (n = 30) were randomly divided into two equal groups: Experimental Group (n = 15) and Control Group (n = 15). All subjects were diagnosed as physically healthy and medically fit to undergo testing and training.

B. Selection of Variables

- The structured short-term Plyometric Training Programme is the independent variable.
- Lower-body explosive power based on its horizontal and vertical components

C. Criterion Measures and Tools

The standing broad jump (SBJ), measured in meters, assesses explosive horizontal power. A standard measuring tape was used to measure the maximal forward jump from the stationary line in 3 trials.

Vertical Jump Test (VJT) measure's vertical explosive ability in centimeters. The difference between the standing reach height and the maximum height attained in a countermovement jump against a wall-mounted scale (highest of three attempts recorded) determined jump height.

D. Training Protocol

The Experimental Group underwent a progressively demanding plyometric training program for four weeks, conducted five days weekly and each lasting approximately 45 minutes. Every training block was followed by a structured warm-up of 10 minutes, plyometric drills of 30 minutes, and a cool-down of 5 minutes. The volume as well as intensity of training progressed and were monitored by the Borg Rating of Perceived Exertion [RPE] scale (1-10). To optimize neural recovery and minimize injury risk, we maintained a strict 1:3 work-to-rest ratio for all plyos.

TABLE I

4-WEEK PLYOMETRIC TRAINING SCHEDULE

Week	Scheduled Exercise Drill	Repetitions / Volume	Intensity (RPE Scale)	Work-to-Rest Ratio
Week 1	Squat Jumps	10 Reps	4-5 (Low Intensity)	1:3
Week 2	Bounding	12 Reps	6-7 (Moderate Intensity)	1:3
Week 3	Depth Jumps	15 Reps	6-7 (Moderate-High)	1:3
Week 4	Hurdle Jumps	15 Reps	8-9 (High Intensity)	1:3

The Control Group took part in their regular physical education classes but did not engage in plyometric conditioning. Participants in both the control and experimental groups were provided with a standard dietary guidelines sheet to ensure that their baseline habits were maintained similarly across both groups throughout the intervention period.

E. Statistical Techniques

The mean and Standard Deviation (SD) were used to compile the descriptive summaries. Because of the pre-test and post-test design, the post hoc test was conducted using the ANCOVA technique. ANCOVA tested the adjusted post-test means by group and provided limited control for pre-test baseline differences. The Levene's test for Homogeneity of Variance was conducted to validate the parametric assumptions. The threshold for statistical significance was set at $\alpha = 0.05$ using IBM SPSS Statistics.

IV. RESULTS & DATA INTERPRETATION

TABLE II

DESCRIPTIVE STATISTICS OF EXPLOSIVE POWER PARAMETERS (N = 30)

Parameter Assessed	Group Category	Pre-Test Mean (± SD)	Post-Test Mean (± SD)	Raw Mean Change
Standing Broad Jump (metres)	Experimental (n=15)	2.03 ± 0.09	2.28 ± 0.10	+0.25 m
	Control (n=15)	2.02 ± 0.08	2.05 ± 0.09	+0.03 m
Vertical Jump Test (cm)	Experimental (n=15)	41.8 ± 2.8	48.6 ± 2.7	+6.8 cm
-	Control (n=15)	42.1 ± 2.6	42.8 ± 2.5	+0.7 cm

Table 2 paints an interesting picture of the data as it shows that there is an improvement shown in the group that underwent the training procedure. The experimental group was able to add an average of 0.25 meters in the horizontal jump and 6.8 cm in the vertical jump, while the control group was statistically stable.

TABLE III

INFERENTIAL ANCOVA SUMMARY FOR STANDING BROAD JUMP

Source of Variance	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	Obtained F-Value	Significance (p-value)
Pre-Test (Covariate)	0.185	1	0.185	10.62	0.003
Group Effect	0.492	1	0.492	28.24	<0.001
Error	0.471	27	0.017	-	-

Adjusted Post-Test Means: Experimental Group = 2.27 m; Control Group = 2.06 m

Explanation of Table 3: At f = (1, 27), the adjusted group effect yielded an F-value of 28.24, which is highly significant ($p < 0.001$). This proves that the 4-week plyometric intervention significantly enhanced horizontal explosive power after mathematically removing the influence of pre-test baselines.

TABLE IV

INFERENTIAL ANCOVA SUMMARY FOR VERTICAL JUMP TEST

Source of Variance	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	Obtained F-Value	Significance (p-value)
Pre-Test (Covariate)	124.51	1	124.51	13.84	0.001
Group Effect	361.92	1	361.92	40.23	<0.001
Error	242.81	27	8.99	-	-

The experimental group scored an average of 48.4 cm in the post-test, while the control group scored 42.9 cm.

In terms of vertical performance, the inferential assessment generated a huge F-value of 40.23 ($p < 0.001$). The statistical certainty of the variation confirms that the physical adaptations observed at vertical explosive jump height were directly caused by the plyometric exercises used in training. Since an integrated ANCOVA design only compared 2 distinct groups, the group F-value directly confirms variance, and no additional post-hoc tracking is necessary.

V. DISCUSSION

The structural data analysis from the current investigation consistently indicates that a brief but intensive 4-week plyometric training micro-cycle produces a statistically significant improvement over standard physical activities in the lower-body explosive power of under-17 school boys ($p < 0.001$). The null hypotheses are rejected, and the Group differences are robust along the horizontal (SBJ: F = 28.24) and the vertical (VJT: F = 40.23) operational scales. This suggests that short-term focused conditioning elicits optimal power improvements in adolescent athletes.

The notable improvements in Standing Broad Jump distance (+0.25 m) and Vertical Jump height (+6.8 cm) were due to the neural and mechanical adaptations forced by plyometric drills. Employs the neurophysiological characteristics of the stretch-shortening cycle (SSC). The muscle spindle stretch reflex is specifically produced during the rapid eccentric phase and improves subsequent concentric M.U. firing. These biological changes help agonist muscle motor unit synchronization, improve the overall rate of force development (RFD), and reduce the inhibition thresholds of Golgi tendon organs, which allow young athletes to produce maximal force against the ground in a few tenths of a second. The findings complement the empirical work of Burgess et al. (2016) and Kubo et al. (2007), who showed that short-to-moderate plyometric blocks will significantly alter musculotendinous stiffness (specifically the Achilles and vastus lateralis tendon) without requiring macroscopic muscular hypertrophy. The quick structural stiffening ensures maximum transfer of kinetic energy from the muscle to the bone. It thus enhances the take-off velocity during jumping events. The study also reflects the developmental model framework of Youth Physical (YPD) development introduced by Lloyd and Oliver (2012), which found that the adolescent neurological system is sensitive and reactive to explosive force stimuli due to natural spikes in neuromuscular coordination linked to maturation.

In addition, the noted changes in performance over a relatively short 4-week period are in line with the short-term effects identified by Asadi (2013) and Meylan and Malatesta (2009). These studies verified that integrating small portions of regular sport practice with intensive, progressive plyometric exercises, undertaken two to three times weekly, is effective in inducing significant gains in power and agility in team-sport athletes. In a managed environment and under controlled conditions, adherence to a precise 1:3 work-to-rest recovery hierarchy and careful tracking of load development through the rate of perceived exertion (RPE) scale enabled the adolescents to successfully internalize high-intensity concentric drills without incurring stress strains or performance stagnation.

VI. CONCLUSION

A four-week plyometric training program that is structured can bring about significant improvement in the lower limb explosive power of under-17 school boys in track and field jumping events.

The experimental group displayed a higher increase in Standing Broad Jump performance compared to the control group ($F = 28.24$, $p < 0.001$). Thus, it demonstrates that horizontal ballistic projection is highly trainable through short-term, specialized drills.

The plyometric group shows significantly higher variation (40.23; $p=0.001$) in vertical jump performance, indicating that countermovement lift capacity improved as stretch-shortening cycle adjustments were enhanced.

The ANCOVA-based inferential analysis confirmed that the performance changes were attributable to structured plyometric exercises and not to differences in baseline characteristics or to normal growth factors.

Due to its low equipment requirements and high time efficiency, this plyometric micro-cycle (4 weeks) is an extremely practical scientific training model that school coaches and PE teachers can resort to due to tight academic curricula or limited institutional facilities.

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