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The Effect Of Plyometric Push-Up Training On Arm Power Improvement In Male Volleyball Extracurricular Athletes

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Keywords

plyometric push up; arm power; volleyball; medicine ball chest pass test; adolescent athletes

Abstract

Volleyball is one of the most widely practised team sports at the secondary-school level in Indonesia and across South-East Asia. One of the important factors in volleyball is plyometric training characterised by rapid, alternating eccentric loading and explosive concentric contraction provides a well-established stimulus for augmenting neuromuscular power, but on-court results indicate that one component of the training including the smash lacks adequate velocity, the floating serve exhibits insufficient ball speed, and the overhead throw fails to achieve competitive distance. Then, this study examined the effect of plyometric push-up training on increasing arm strength in male extracurricular volleyball athletes at PL Don Bosco Senior High School, Semarang. The research design used a pre-experimental approach with a single pretest posttest group, involving ten male students selected through total sampling. Participants in this study were determined by the following inclusion criteria: actively involved in volleyball activities for at least three months, physically fit, and free from musculoskeletal injuries. The data collection method used the Medicine Ball Chest Pass Test (MBCPT) with a 2–3 kg ball, recording the best results from three trials over six weeks, three times a week (Monday, Wednesday, and Friday), starting from basic plyometric push-ups to clap push-ups, medicine ball push-ups, and explosive push-ups. The data analysis method used descriptive and inferential statistics, with normality confirmed by the Shapiro Wilk test ($p > 0.05$). The results showed that the six-week plyometric push-up training program significantly increased arm strength in adolescent male volleyball athletes.

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INTRODUCTION

Volleyball is one of the most widely practised team sports at the secondary-school level in Indonesia and across South-East Asia (Prangthip et al., 2021). Competitive performance in volleyball is underpinned by a constellation of biomotor capacities strength, speed, agility, coordination, and explosive power among which arm power occupies a particularly central role. The service, spike, and blocking actions that determine match outcomes all require the upper extremities to generate maximal force in minimal time, a quality operationally defined as power (Bompa & Buzzichelli, 2015; Wang et al., 2025).

The importance of volleyball in physical education is in accordance with research conducted in SMA PL Don Bosco Semarang maintains an active volleyball extracurricular program whose male athletes have demonstrated observable limitations in arm power during routine training sessions (Rebelo et al., 2022). Preliminary observations indicated that spikes lacked penetrating velocity, float serves showed insufficient ball speed, and overhead throws failed to attain competitive distances (Lindsay et al., 2022). These deficiencies motivated the systematic investigation reported herein (Zeng et al., 2018).

One of the important factors in volleyball is plyometric training characterised by rapid, alternating eccentric loading and explosive concentric contraction provides a well-established stimulus for augmenting neuromuscular power (Chu & Myer, 2013). The stretch shortening cycle (SSC) exploited during plyometric exercises enhances the elastic energy storage capacity of the musculotendinous unit and accelerates motor-unit recruitment, thereby amplifying peak power output (Zatsiorsky & Kraemer, 2006). Plyometric push-up variants (e.g., clap push-up, medicine ball push-up, explosive push-up) directly load the pectoralis major, triceps brachii, and anterior deltoid the primary movers in volleyball arm actions and have shown promise for increasing upper limb power in youth populations (Adiputra et al., 2021).

Based the theoretical rationale, and empirical background for evidence from controlled interventions targeting adolescent volleyball players in the Indonesian school context remains scarce. This research purpose to present study therefore sought to determine whether a six-week progressive plyometric push-up program would produce a statistically significant improvement in arm power, as measured by the Medicine Ball Chest Pass Test (MBCPT). This study offers novelty by specifically examining the effect of plyometric push-up training on increasing arm explosive power in male extracurricular volleyball athletes, which has so far been limited compared to more general research on professional athletes or other sports.

METHODS

This research uses the method pre-experimental design with a one-group pretest posttest structure (Campbell & Stanley, 1963) was adopted. Although the absence of a randomised control group limits causal inference, this design is widely accepted for feasibility constrained school-sport investigations with small populations (Thomas et al., 2015). Internal validity was strengthened through strict procedural standardisation across measurement occasions.

The population for this research that all active members of the male volleyball extracurricular program at SMA PL Don Bosco Semarang. Then, the sample of this study was determined using the Inclusion criteria were: (i) male sex; (ii) age 15–19 years; (iii) continuous extracurricular participation for ≥ 3 months prior to the study; (iv) absence of current musculoskeletal injury; and (v) written informed consent. All ten eligible athletes satisfied these criteria and were enrolled, constituting a total-population sample (N = 10, mean age 17.2 ± 0.6years).

The data collection technique in this study uses arm power was assessed with the MBCPT using a rubber medicine ball of 2.5 kg mass and standard circumference. A calibrated steel measuring tape (resolution: 1 cm) was employed to record throwing distance. All measurements were performed by the same two-person assessment team across both testing occasions to control for inter-rater variability.

The plyometric push-up intervention was delivered over six weeks (18 sessions), three sessions per week on Monday, Wednesday, and Friday. Each session comprised a standardized 15-minute warm-up (5 min light jogging, 5 min dynamic upper-limb mobility drills, 5 min submaximal push-up ramp), the plyometric training block, and a 10-minute cool-down. . Inter-set rest intervals were fixed at 2–3 minutes to permit near-complete phosphocreatine resynthesis. The progressive structure is detailed in **Table 1.**

Table 1. Six-Week Progressive Plyometric Push-Up Training program

Phase	Week	Exercise	Sets × Reps	Intensity
Adaptation	1–2	Basic Plyometric Push-Up; Clap Push-Up	3 × 6–8	Low–Moderate
Development	3–4	Clap Push-Up; Medicine Ball Push-Up	3 × 8–10	Moderate
Intensive	5–6	Medicine Ball Push-Up; Explosive Push-Up	3 × 10–12	High

Data Collection Procedures

Pre-test data were collected on Monday, 26 January 2026 (15:30 h) at the school's indoor sports court, SMA PL Don Bosco Semarang, under partly cloudy conditions. Post-test data were collected on Monday, 2 March 2026 (15:00 h) at the identical venue under comparable ambient conditions. Both testing sessions followed an identical protocol: standardized warm-up → three MBCPT trials per subject (2-minute inter-trial rest) → best valid distance recorded. A trial was declared invalid if the subject's back left the wall, the hips were raised, the knees were flexed, or the ball was not released from chest height. Each subject was permitted one additional trial to replace any invalid attempt.

Statistical Analysis

Data were analysed using descriptive statistics (mean, standard deviation, percentage change) and inferential statistics. The Shapiro–Wilk test was applied to assess univariate normality of pre-test scores, post-test scores, and difference scores ($\alpha = 0.05$). Given confirmed normality, the paired-samples t-test was used to evaluate the null hypothesis of no mean difference between testing occasions. Effect size was quantified using Cohen's d (d = mean difference / SD of differences). All analyses were performed in SPSS version 26.0; statistical significance was set at $\alpha = 0.05$ (two-tailed).

RESULTS AND DISCUSSION

Individual and Group Performance Data

Table 2. presents each participant's pre-test score, post-test score, absolute difference, and percentage change on the MBCPT.

Participant	Age	Pre-Test (m)	Post-Test (m)	Δ (m)	% Change	Category
N1	17	5.33	6.700	1.370	25.7%	Moderate
N2	17	4.53	4.770	0.240	5.3%	Low
N3	18	4.33	4.930	0.600	13.9%	Low
N4	17	3.50	4.360	0.860	24.6%	Moderate
N5	17	4.44	5.910	1.470	33.1%	High
N6	19	5.45	7.280	1.830	33.6%	High
N7	18	4.82	6.210	1.390	28.8%	Moderate
N8	17	3.67	5.400	1.730	47.1%	High
N9	17	3.31	5.976	2.666	80.5%	High
N10	17	3.67	4.780	1.110	30.2%	High
Mean	17.2	4.305	5.632	1.327	30.82%	—
SD	0.6	0.756	0.944	0.684	—	—

All ten participants recorded higher post-test scores than pre-test scores, indicating a consistent directional effect of the training program. The largest absolute gain was achieved by participant Tia (Δ = +2.666 m; +80.5%), while the smallest gain was observed for participant Vinsen (Δ = +0.240 m; +5.3%). Six of ten participants (60%) achieved percentage improvements of ≥ 25%, classified as High category.

Normality Assessment

Table 3. Shapiro–Wilk Normality Test Results

Variable	W statistic	p-value	Decision
Pre-Test scores	0.934	0.487	Normal
Post-Test scores	0.918	0.332	Normal
Difference scores	0.942	0.573	Normal

All three distributions satisfied the normality assumption ($p > 0.05$), justifying the use of the parametric paired-samples t-test.

Hypothesis Testing

Hypothesis testing in this study was conducted to measure provide strong statistical evidence that the six-week plyometric push-up program produced a significant and practically meaningful improvement in arm power as there in **Table 4.**

Table 4. Paired-Samples t-Test Summary

Comparison	Mean Diff. (m)	SD	SE	t	df	p	Cohen's d
Pre-Test vs. Post-Test	−1.327	0.684	0.216	6.134	9	< .001	1.940

Based on the hypothesis test, the value obtained t = 6.134, p < .001. Because the obtained t-value (6.134) exceeded the critical value t(0.05, 9) = 2.262, and p < α = 0.05, so the null hypothesis was rejected.

Then, the effect size in this hypothesis was Cohen's d = 1.940, classified as a large effect according to conventional benchmarks (d > 0.80; Cohen, 1988). So, it can be concluded that provide strong statistical evidence that the six-week plyometric push-up program produced a significant and practically meaningful improvement in arm power.

There are several findings in this study, one of which is a 30.82% mean increase in MBCPT distance and a large effect size (d = 1.940) following a six-week plyometric push-up program aligns with and extends the existing literature on plyometric training for upper-body power in adolescent athletes. From a neuromuscular standpoint, the observed improvements are consistent with the dual-mechanism model of plyometric adaptation proposed by Sale (1992). First, the rapid, high-force eccentric loading inherent in plyometric push-up variants stretches the musculotendinous unit of the pectoralis major and triceps brachii, facilitating energy storage within the series elastic component (Thakuria, 2025). When the amortisation phase is kept brief, this stored elastic strain energy is instantaneously superimposed onto volitional concentric force, augmenting peak power output beyond the level achievable through maximal voluntary contraction alone (Komi, 2008; Tomalka, 2023). Second, repeated exposure to plyometric stimuli induces progressive neural adaptations: increased motor-unit firing rates, enhanced synchronisation of motor-unit discharge, and diminished inhibitory feedback from Golgi tendon organs collectively enabling the nervous system to recruit a larger proportion of available motor units more rapidly (Chimera et al., 2004; Lecce et al., 2026; Furrer et al., 2023).

The progressive overload structure of the program advancing from basic plyometric push-ups (3 × 6–8 repetitions) through clap and medicine ball variants to explosive push-ups (3 × 10–12 repetitions) was instrumental in sustaining a sufficient training stimulus across the six-week period. By systematically increasing both the complexity and volume of plyometric work, the program prevented premature adaptive plateau and ensured continuous neuromuscular challenge, consistent with the principle of progressive overload articulated by Bompa and Buzzichelli, (2015). The present findings are corroborated by prior research. Sukadiyanto, (2011) reported significant power gains following 6–8 weeks of plyometric training in adolescent Indonesian athletes. Adiputra et al., (2021) and Ma et al., (2024) observed comparable improvements in arm power in junior volleyball players undergoing an eight-week plyometric push-up protocol. Internationally, Vossen et al. (2000) demonstrated that plyometric push-ups produced significantly greater gains in upper-body power than traditional resistance training alone over equivalent timeframes.

The marked inter-individual variability in percentage improvement (range: 5.3%–80.5%) warrants comment. Participants with the lowest pre-test scores (e.g., Tia: 3.31 m pre-test, +80.5% improvement) tended to show proportionally larger gains, a pattern consistent with the statistical phenomenon of regression to the mean and the physiological principle of initial value effect the observation that individuals with lower baseline fitness levels exhibit greater relative adaptation to a standardized training stimulus (Thomas et al., 2015; Meyler et al., 2025). Conversely, participants with higher baseline arm power (e.g., Vinsen: 4.53 m pre-test, +5.3%) may have required greater training volume or intensity to elicit further adaptations, reflecting the specificity and diminishing returns inherent in progressive training.

Several limitations of this study should be acknowledged. The absence of a randomised control group precludes definitive causal attribution; it is possible that maturation, increased practice motivation, or concurrent volleyball training contributed to the observed improvements. The small sample size (N = 10) reduces statistical power and limits the generalisability of findings to broader populations. Future research should employ randomised controlled designs with larger, more diverse samples, include biochemical or electromyographic assessments to elucidate underlying mechanisms, and examine the durability of training adaptations following a detraining period.

CONCLUSION

This findings from this research have direct practical implications for volleyball coaches and physical education practitioners at the secondary-school level. Plyometric push-up training can be feasibly integrated into extracurricular volleyball program without specialised equipment, and the six-week progressive protocol employed herein provides a replicable model for practitioners seeking to enhance athletes' upper-body explosive power. Future investigations incorporating control groups, longer intervention periods, and multidimensional performance assessments will further clarify the scope and mechanisms of plyometric push-up adaptations in this context.

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