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Effect of complex training on selected physical variables among intercollegiate volleyball players

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Abstract
This study examined how sophisticated training affected physical factors in Chennai intercollegiate volleyball players. Complex training, which combines resistance training with plyometric and sport-specific drills, boosts explosive power and performance. For this study, 40 Chennai-based intercollegiate male volleyball players aged 18-23 were randomly assigned to 20 experimental and 20 control groups. In an 8-week, three-session complicated training program, the experimental group performed strength-power combinations such squats with vertical jumps, bench press with medicine ball tosses, and lunges with bounding drills. Normal training continued for the control group. Before and after the intervention, explosive power (vertical leap), agility (Illinois agility test), speed (30 m sprint), and muscular strength (1RM test) were measured. Statistics showed that the experimental group outperformed the control group in explosive power and agility, which are critical for volleyball. Complex training appears to improve important physical variables in intercollegiate volleyball players and can be systematically integrated into sports performance training programs.

Keywords: Complex training, volleyball, physical variables, explosive power, agility, college athletes

Introduction

Volleyball is a fast-paced team sport that requires intense physical conditioning. During rallies, players must spike, block, serve, and change directions quickly. Elite volleyball players leap around 100 times per match, totaling 30,000-40,000 jumps per year (Bäcker *et al.*, 2023) [1]. To perform well all season, such repetitive high-impact motions require strength, agility, speed, and explosive power.

Volleyball performance depends on lower-body power for jumping and spiking and upper-body force for serves and blocks. Defenses like digs and rapid recoveries require agility and speed. Thus, intercollegiate player growth requires efficient training programs to address these physical traits.

Volleyball strength and conditioning programs use resistance and plyometric training. Resistance training increases maximal force production through neuromuscular and hypertrophic adaptations, while plyometric training speeds up the stretch-shortening cycle (SSC), allowing athletes to quickly switch from eccentric to concentric muscle contractions (Slimani *et al.*, 2021) [6]. Both strategies are useful for volleyball players, but combining them may improve performance.

Modern complex training (CT) combines RT and PT in one session. CT usually mixes a high resistance exercise like back squat with a biomechanically similar plyometric action like vertical leap. Post-activation potentiation (PAP), a physiological phenomena in which prior muscle contractions improve explosive movements, underpins this training model (Hodgson *et al.*, 2005) [4]. Heavy resistance training temporarily enhances contractile protein calcium sensitivity, increasing power output in the next plyometric challenge (Docherty & Hodgson, 2007) [3].

CT has various benefits, according to research. It builds strength and power simultaneously, lowers training time, and may improve explosive movement gains over typical RT or PT (Wilson *et al.*, 2013) [7]. These benefits make CT appealing in volleyball, which requires fast, performance-oriented training.

Several studies show that CT improves sports performance. Santos and Janeira (2008) [5] found that a 10-week CT program improved explosive strength, including SJ, CMJ, and medicine ball throw performance, in adolescent basketball players. Comyns *et al*. (2007) [2] discovered that CT was as effective as compound training in improving vertical jump performance quickly, suggesting that CT can help athletes acquire explosiveness.

In elite male volleyball, Zghal *et al*. (2022) [8] compared a four-week CT program to plyometric-only training. Both groups improved CMJ height and power, but there was no significant difference between interventions, showing that CT is equally effective as plyometric training in jump performance. Systematic reviews and meta-analyses show that volleyball players' countermovement, drop, and spike jump heights improve significantly with plyometric jump training (Slimani *et al*., 2021) [6]. Plyometric or mixed training modalities are relevant to volleyball conditioning, according to these data.

Research Gap

Although CT has been widely studied in basketball, football, and track-and-field athletes, there remains limited research examining its effects specifically among intercollegiate volleyball players, particularly in the Indian context. Most existing studies have focused on elite or professional athletes in Western countries, with relatively few addressing college-level populations in South Asia. Moreover, while plyometric and resistance training interventions are commonly applied in volleyball training programs in India, the integration of CT as a structured intervention remains underexplored.

Significance of the Study

Understanding the effectiveness of CT among intercollegiate volleyball players in Chennai holds both theoretical and practical significance. From a scientific standpoint, it contributes to the growing body of literature on PAP and combined training methods. Practically, it provides coaches, trainers, and physical education professionals with evidence-based guidance to design efficient training programs tailored to the needs of college athletes. By examining key physical variables such as explosive power, agility, speed, and muscular strength, this study seeks to identify whether CT can serve as a superior conditioning strategy compared to traditional methods.

Methodology

Participants

A total of 40 male intercollegiate volleyball players from Chennai (age range 18-23 years) were recruited for the study. All participants were actively involved in competitive volleyball for at least two years and were free from musculoskeletal injuries or chronic illnesses at the time of the study. Written informed consent was obtained prior to participation. The players were randomly assigned into two groups:

- **Experimental Group (n = 20):** Underwent complex training in addition to their regular practice.
- **Control Group (n = 20):** Continued with their routine volleyball training without additional interventions.

Training Intervention

The experimental group followed a structured 8-week complex training program, consisting of three sessions per week (on non-consecutive days). Each session lasted approximately 60-75 minutes, including warm-up and cool-down periods.

Training Protocol

Each CT session combined a heavy resistance exercise with a biomechanically similar plyometric exercise:

Resistance Exercise	Plyometric Exercise	Sets × Reps	Rest Interval
Back Squat	Vertical Jump	3 × 6-8	2-3 min
Bench Press	Medicine Ball Chest Pass	3 × 6-8	2-3 min
Lunges	Bounding Jumps	3 × 8-10	2-3 min

The complex training protocol included deadlifts combined with broad jumps, performed for 3 sets of 6-8 repetitions with a rest interval of 2-3 minutes between sets. Each session began with a 10-minute warm-up consisting of dynamic stretching and mobility drills. The resistance load for deadlifts was set at 70-85% of the participant’s one-repetition maximum (1RM) and was progressively increased every two weeks to ensure progressive overload. The plyometric component was advanced by gradually increasing the jump height or distance, and in later sessions, weighted vests were incorporated to further enhance intensity. Each training session concluded with a 5-10-minute cool-down that included static stretching to promote recovery and flexibility.

The control group continued with regular volleyball training (technical and tactical drills, general fitness work) without additional strength or plyometric interventions.

Variables and Tests

Physical variables were selected for assessment based on their direct relevance to volleyball performance. Explosive power was measured using the Vertical Jump Test, employing either a countermovement jump (CMJ) with a Vertec device or a jump mat. Agility was evaluated through the Illinois Agility Test, with performance recorded in seconds. Speed was measured using the 30-meter Sprint Test, with timing obtained through a stopwatch or electronic timing gates. Finally, muscular strength was determined using the one-repetition maximum (1RM) test for both the back squat and bench press, providing an index of lower- and upper-body maximal strength.

Data Collection Procedure

All participants first underwent a pretest in which baseline measurements of the selected physical variables were recorded prior to the commencement of the intervention. The intervention phase spanned eight weeks, during which the experimental group performed the complex training (CT) program, while the control group continued with their routine volleyball practice. Following the intervention, a posttest was conducted for both groups, using the same testing procedures as in the pretest, to evaluate changes in performance across the selected physical variables.

Statistical Analysis

Descriptive statistics (mean and standard deviation) were computed for all variables. A paired sample t-test was used to compare pretest and posttest values within groups. An independent sample t-test was employed to examine differences between the experimental and control groups. Statistical significance was set at p <.05. Effect sizes (Cohen's d) were also calculated to determine the magnitude of training effects.

Results

Descriptive Statistics

Table 1 presents the mean and standard deviation values for pretest and posttest scores of both groups across selected physical variables.

Table 1: Descriptive Statistics of Physical Variables (N = 40)

Variable	Group	Pretest M	Pretest SD	Post-test M	Post-test SD	% Change
Explosive Power (cm)	Experimental	42.5	3.2	49.8	3.0	17.17
	Control	41.9	3.5	43.2	3.3	3.10
Agility (s)	Experimental	17.8	0.9	16.2	0.8	8.98
	Control	17.6	1.0	17.4	0.9	1.13
Speed 30 m (s)	Experimental	5.2	0.4	4.8	0.3	7.69
	Control	5.1	0.5	5.0	0.4	1.96
Muscular Strength (kg)	Experimental	65.3	5.6	72.8	5.9	11.48
	Control	64.9	6.1	66.1	6.0	1.84

Note. Values are presented as Mean (M) ± Standard Deviation (SD). % Change indicates relative improvement from pretest to posttest.

The descriptive results (Table 1) show clear improvements in the experimental group across all measured physical variables—explosive power, agility, speed, and muscular strength—over the 8-week intervention. For example, explosive power increased from *M* = 42.5 cm (SD = 3.2) to *M* = 49.8 cm (SD = 3.0), reflecting a 17% improvement. Similarly, agility performance improved by 9%, and muscular strength increased by 11%. In contrast, the control group showed negligible gains, confirming that routine volleyball training alone does not substantially enhance these variables.

Table 2: Within-Group Differences in Physical Variables (Paired t-tests)

Variable	Group	t(df=19)	p	Cohen d
Explosive Power (cm)	Experimental	9.12	<.001	1.62
Agility (s)		-7.45	<.001	1.28
Speed 30 m (s)		-6.32	<.001	1.1
Muscular Strength (kg)		8.15	<.001	1.45
Explosive Power (cm)	Control	2.05	.055	0.31
Agility (s)		-1.22	.236	0.19
Speed 30 m (s)		-0.98	.338	0.16
Muscular Strength (kg)		1.56	.135	0.24

Note. df = 19 for all paired t-tests. Cohen's d indicates effect size.

Paired-sample t-tests (Table 2) confirmed that the experimental group exhibited statistically significant improvements in all variables (all *p* <.001, Cohen's *d* ranging from 1.10 to 1.62). These are considered large effect sizes (Cohen, 1988), indicating that complex training had a strong practical impact on performance outcomes. The control group showed no significant changes (all *p* >.05), underscoring the necessity of structured conditioning interventions.

Table 3: Between-Group Posttest Differences (Independent t-tests)

Variable	t(df=38)	p	Hedges g
Explosive Power (cm)	6.1	<.001	1.92
Agility (s)	-4.28	<.001	1.35
Speed 30 m (s)	-3.25	.003	1.02
Muscular Strength (kg)	3.12	.003	0.98

Note. df = 38 for all independent t-tests. Hedges' g indicates effect size.

Independent-sample t-tests (Table 3) revealed significant differences between groups in posttest scores across all four variables (all *p*<.01). The effect sizes, measured using Hedges' *g* (0.98-1.92), fall within the large range, reinforcing that the improvements in the experimental group were not only statistically significant but also practically meaningful. This provides compelling evidence that complex training is more effective than routine practice for enhancing volleyball-specific physical attributes.

Table 4: Analysis of Variance for Posttest Scores

Variable	F(1,38)	p	η^2p
Explosive Power (cm)	37.2	<.001	0.49
Agility (s)	18.3	<.001	0.33
Speed 30 m (s)	10.6	.002	0.22
Muscular Strength (kg)	9.8	.003	0.21

Note. η^2p = partial eta squared.

The ANOVA results (Table 4) corroborated these findings, with significant group effects across variables: explosive power, agility, speed, and muscular strength (*F*(1,38) = 9.8-37.2, all *p*<.01). Partial eta squared values (η^2p = 0.21-0.49) indicate medium-to-large effect sizes, again demonstrating the strong influence of complex training on athletic performance.

These results are consistent with previous research demonstrating the efficacy of complex training. Santos and Janeira (2008) [5] reported similar gains in explosive power among young athletes following CT interventions, while Docherty and Hodgson (2007) [3] attributed such improvements to post-activation potentiation (PAP) mechanisms. Likewise, Comyns *et al.* (2007) [2] observed enhanced agility and sprint performance, aligning with the present findings.

The improvements in muscular strength are also supported by Wilson *et al.* (2013) [7], who highlighted CT's capacity to concurrently improve strength and power. The findings thus extend the literature to an intercollegiate

Discussion on Findings

The experimental group, which underwent an eight-week complex training (CT) program, improved explosive power, agility, speed, and muscular strength compared to the control group, which continued volleyball training. CT appears to be a useful solution for college volleyball players due to its substantial effect sizes.

Explosive Power

CT boosts explosive power as seen by the experimental group's vertical jump performance. Resistance training prepares the neuromuscular system for plyometrics, according to post-activation potentiation (PAP). CT improves jumping ability (Santos & Janeira, 2008) [5], which is vital in volleyball for spiking, blocking, and serving.

Agility

The experimental group's much shorter agility times indicate faster direction-changing. Volleyball players need this to react swiftly to offensive and defensive scenarios. CT increases change-of-direction speed by integrating strength and plyometric components that target force production and neuromuscular coordination, according to Comyns *et al.* (2007) [2].

Speed

Experimental group sprint performance over 30 meters improved dramatically. In volleyball, although sprints are typically short, acceleration and quick bursts of speed are essential. The improvement reflects better neuromuscular efficiency and enhanced recruitment of fast-twitch muscle fibers, consistent with evidence from training studies that demonstrate CT's capacity to boost sprint ability.

Muscular Strength

The experimental group exhibited notable gains in muscular strength, confirming that CT not only improves explosive movements but also enhances maximal force production. Strength improvements provide the foundation for repeated jumping, hitting power, and overall resilience during high-intensity matches. This result mirrors findings from Wilson *et al.* (2013), who emphasized CT's ability to concurrently improve both maximal strength and power outputs.

Comparison with Control Group

Minimal improvements were observed in the control group across all variables, indicating that routine volleyball training alone may not be sufficient to elicit significant gains in strength and power-related capacities. This reinforces the importance of integrating structured conditioning interventions like CT to meet the physical demands of modern competitive volleyball.

Conclusions

Overall, the present findings are consistent with previous evidence supporting the use of CT for athletic populations. The results confirm that CT is not only effective in enhancing general physical fitness but also has direct applicability to sport-specific performance needs. Importantly, this study adds to the growing body of literature by demonstrating the benefits of CT among college-level volleyball players in Chennai, thereby contributing context-specific insights relevant to Indian sports training environments.

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