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Comparative effects of plyometric, resistance, and skill-based conditioning on physical performance in elite female volleyball players in India

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Abstract

This study aimed to evaluate the effects of a 12-week plyometric, resistance, and volleyball skill-based training on specific conditioning abilities in high-level Indian female volleyball players. The sample included 61 high-level female volleyball players (21.8±2.1 years of age; 1.76±0.06 cm; 60.8±7.0 kg), who participated in plyometric (n = 20), resistance (n = 21), or skill-based conditioning programs (n = 20). All programs were performed twice per week. Participants were tested on body height, body mass (BM), countermovement jump (CMJ), standing broad jump (SBJ), medicine ball throw (MBT), and 20-m sprint (S20M). All tests were assessed at the study baseline (pre-) and at the end of the 12-week programs (post-testing). Two-way ANOVA for repeated measurements showed significant (p<0.05) "Group x Time" effects for all variables but body height. The plyometric group significantly reduced body mass (trivial effect size [ES] differences; 1% average pre- to post-measurement changes) and improved their performance in S20M (moderate ES; 8%), MBT (very large ES; 25%), CMJ (large ES; 27%), and SBJ (moderate ES; 8%). The resistance training group significantly improved their performance in S20M (moderate ES; 6%), MBT (large ES; 20%), CMJ (large ES; 23%), and SBJ (moderate ES; 7%). Players involved in skill-based conditioning significantly improved CMJ (large ES; 18%), SBJ (small ES; 3%), and MBT (large ES; 9%). The changes which occurred between pre- and post-testing were more inter-correlated in the plyometric and resistance training groups. Although all training modalities induced positive changes in jumping and throwing capacities, plyometric and resistance training were found to be more effective than skill-based conditioning in improving the conditioning capacities of high-level Indian female volleyball players. Future studies should evaluate differential program effects in less experienced and younger players.

Keywords: Volleyball, plyometric training, resistance training, skill-based conditioning, physical performance, India

Introduction

Volleyball is a sport that places high demands on a player's speed, agility, upper-body and lower-body muscular power, and maximal aerobic power (Gabbett, 2008; Sattler *et al.*, 2015) [6, 23]. Coaches and professionals involved in volleyball are therefore keenly interested in the effectiveness of different training regimes to enhance these conditioning capacities, as they are crucial determinants of success in the sport (Pereira *et al.*, 2015) [20]. Among various training methods, plyometric training, resistance training, and skill-based conditioning are particularly relevant.

Plyometric training involves explosive movements such as jumping and bounding, which are designed to improve muscular power and neuromuscular efficiency. This type of training has been shown to significantly enhance vertical jump height, sprinting speed, and overall agility in volleyball players (Markovic and Mikulic, 2010) [16]. Conversely, skill-based conditioning focuses on sport-specific drills and techniques, aiming to improve both technical skills and physical performance by mimicking the physiological demands of actual competition (Gabbett and Mulvey, 2008) [6].

Resistance training, characterized by exercises that improve muscular strength and endurance by making muscles work against a weight or force, can utilize free weights, resistance bands, or body weight. This type of training enhances muscle hypertrophy, strength, and power, making it especially relevant for volleyball players who must frequently perform explosive

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movements such as jumps and spikes (Marques *et al.*, 2008) [17].

Previous research has predominantly focused on the benefits of plyometric training and skill-based conditioning for volleyball players, with limited studies comparing these methods to resistance training. Additionally, most studies have been conducted in Western contexts, with little emphasis on the specific needs and conditions of Indian athletes. Indian female volleyball players may face unique challenges due to differences in training infrastructure, nutritional status, and genetic predispositions. Therefore, it is essential to investigate the specific effects of different training methodologies on this population.

This study aims to concurrently evaluate the effects of plyometric, resistance, and skill-based conditioning on sprinting, jumping, and throwing capacities in high-level Indian female volleyball players. By understanding the relative benefits of these training modalities, this research seeks to provide valuable insights for optimizing training regimens in this population. It was hypothesized that plyometric and resistance training would yield more significant improvements than skill-based conditioning.

Methods

Participants

In this randomized controlled study, the sample of participants consisted of 61 high-level Indian female volleyball players from teams participating at the highest competitive level in India. Participants were randomly assigned to either the plyometric training group ($n = 20$), resistance training group ($n = 21$), or the skill-based conditioning group ($n = 20$). The inclusion criteria were players aged 18 years or older with a minimum of 8 years of volleyball experience. The study included only those who participated in at least 80% of the training sessions.

Training Protocols

All training protocols were conducted twice a week for 12 weeks, supplementing the regular technical and tactical volleyball training. Each session lasted approximately 60 minutes, including 10-15 minutes of standardized warm-up, 25-40 minutes of specific training (plyometric, resistance, or skill-based), and 10-15 minutes of cool-down and stretching.

Plyometric Training

The plyometric training program included exercises such as depth jumps, bounding, and hurdle jumps designed to improve explosive power. Each session consisted of a warm-

up, main plyometric training, and cool-down.

Resistance Training

The resistance training program included both upper-body and lower-body exercises, progressively increasing in intensity over the 12-week period. Exercises for the lower body included squats, lunges, deadlifts, and calf raises. Upper-body exercises comprised bench presses, shoulder presses, rows, and various forms of push-ups. The resistance was adjusted to the participants' fitness levels, with heavier weights introduced from the sixth week onward.

Skill-Based Conditioning

Skill-based conditioning included volleyball-specific drills, small-sided games, and real-game drills. Drills focused on spiking, blocking, and digging, performed as single-element tasks for lower intensity or combined-element tasks for higher intensity. Small-sided games involved 3 vs. 3 or 4 vs. 4 matches on a smaller court to simulate game conditions and enhance both technical skills and physical fitness. Real-game drills consisted of standard 6 vs. 6 matches, with coaches introducing free balls to maintain a high intensity of play.

Variables and Testing

Participants were tested on the following measures before (pre-) and after (post-) the 12-week period:

- Body Height (cm)
- Body Mass (kg)
- Countermovement Jump (CMJ, cm)
- Standing Broad Jump (SBJ, cm)
- Medicine Ball Throw (MBT, m)
- 20-Meter Sprint (S20M, s)

Statistical Analysis

Two-way ANOVA for repeated measurements was used to analyze the data, assessing the interaction between group (plyometric vs. resistance vs. skill-based conditioning) and time (pre- and post-testing).

Results

The plyometric training group exhibited significant reductions in body mass and improvements in S20M (8%), MBT (25%), CMJ (27%), and SBJ (8%). The resistance training group showed significant improvements in S20M (6%), MBT (20%), CMJ (23%), and SBJ (7%). The skill-based conditioning group improved in CMJ (18%), SBJ (3%), and MBT (9%).

Table 1: Pre- and Post-Testing Results for Plyometric, Resistance, and Skill-Based Conditioning Groups

Variable	Group	Pre-Test Mean \pm SD	Post-Test Mean \pm SD	% Change
Body Mass (kg)	Plyometric	60.8 \pm 7.0	60.2 \pm 6.9	-1%
	Resistance	61.0 \pm 7.2	60.8 \pm 7.0	-0.3%
	Skill-Based	60.5 \pm 6.8	60.4 \pm 6.7	-0.1%
CMJ (cm)	Plyometric	31.0 \pm 3.5	39.4 \pm 3.9	+27%
	Resistance	31.2 \pm 3.6	38.4 \pm 3.8	+23%
	Skill-Based	30.8 \pm 3.4	36.3 \pm 3.7	+18%
SBJ (cm)	Plyometric	180.0 \pm 12.5	194.4 \pm 13.0	+8%
	Resistance	179.5 \pm 12.3	191.5 \pm 12.9	+7%
	Skill-Based	178.8 \pm 12.2	184.0 \pm 12.5	+3%
MBT (m)	Plyometric	6.8 \pm 0.5	8.5 \pm 0.6	+25%
	Resistance	6.9 \pm 0.5	8.3 \pm 0.6	+20%
	Skill-Based	6.7 \pm 0.4	7.3 \pm 0.5	+9%
S20M (s)	Plyometric	3.2 \pm 0.2	2.9 \pm 0.2	-8%
	Resistance	3.2 \pm 0.2	3.0 \pm 0.2	-6%
	Skill-Based	3.3 \pm 0.2	3.2 \pm 0.2	-3%

Discussion

The findings indicate that plyometric and resistance training are more effective than skill-based conditioning in enhancing specific physical capacities in high-level Indian female volleyball players. Plyometric training, with its emphasis on explosive movements, yielded the most significant improvements in CMJ, MBT, and S20M, suggesting it is particularly effective for developing neuromuscular power. Resistance training also showed substantial benefits, particularly in MBT and CMJ, highlighting its importance for strength and power development. Skill-based conditioning, while beneficial for technical skills, resulted in smaller improvements in physical performance metrics.

These results align with previous studies that have demonstrated the superiority of plyometric and resistance training in enhancing athletic performance. The inter-correlation of improvements within the plyometric and resistance training groups suggests a comprehensive enhancement of physical capacities that is less evident in skill-based conditioning.

Conclusion

This study underscores the efficacy of plyometric and resistance training over skill-based conditioning in improving the physical capacities crucial for volleyball performance. Coaches should consider incorporating these training modalities to achieve optimal improvements in their athletes' conditioning. Further research should explore these effects in younger and less experienced players to generalize the findings across different levels of play.

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