OPEN ACCESS JOURNALS
Indiana Journal of Agriculture and Life Sciences
Abbreviate Tittle- Ind J Agri Life Sci
ISSN *(Online)*- 2583-1623
Journal Homepage Link- https://indianapublications.com/journal/IJALS
DOI- https://doi.org/10.5281/zenodo.17208391

INDIANA PUBLICATIONS
PRODUCTIVE AND QUALITY RESEARCH

Research Article

ICFFL Goa Conference|2025

Effect of Pilates and Plyometric Training on Skill Performance of Volleyball Players

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Article History
Received: 01.07.2025
Accepted: 20.08.2025
Published: 25.09.2025

Citation
Taywade, V. V., Bhonsale, S. S., Mardikar, M. A., Yadav, K. N. (2025). Effect of Pilates and Plyometric Training on Skill Performance of Volleyball Players. Goa Conference 2025 Fit for Life: Empowering Youth Through Physical Education, Sports and Traditional Sports. *Indiana Journal of Agriculture and Life Sciences,* 18-23. Indiana Publications.

Abstract: This study aimed to evaluate the combined effects of Pilates and Plyometric training on the skill performance of volleyball players. Sixty competitive volleyball players aged 18-25 years were randomly assigned to three groups: Pilates, Plyometric, and Combined Training. Over a 12-week period, participants underwent structured training programs, with assessments conducted at baseline, mid-point, and post-intervention. Skill performance metrics, including serve accuracy, spike power, and agility, were measured using standardized tools and methods. The results demonstrated significant improvements in the Combined Training group compared to the individual training groups. Serve accuracy increased from 68.2 ± 5.3% to 78.6 ± 4.5% ($p < 0.001$, Cohen's $d = 1.89$), spike power improved from 81.1 ± 4.6 km/h to 89.8 ± 4.2 km/h ($p < 0.001$, Cohen's $d = 1.96$), and agility times decreased from 9.8 ± 0.5 seconds to 8.7 ± 0.4 seconds ($p < 0.001$, Cohen's $d = 2.10$). The study highlights the superior benefits of integrating Pilates and Plyometric exercises, resulting in enhanced skill performance metrics. These findings provide valuable insights for developing effective training regimens for volleyball players and underscore the potential of combined training approaches in optimizing athletic performance. Future research should explore long-term effects and broader applications of this integrated training methodology.

Keywords: Effect of Pilates, Plyometric Training, Skill Performance, Volleyball Players

INTRODUCTION

Physical training is paramount in enhancing athletic performance across all sports, including volleyball. In volleyball, physical conditioning is essential for improving key skills such as spiking, serving, blocking, and diving. Studies have shown that well-rounded physical training programs can significantly enhance an athlete's strength, endurance, agility, and overall performance on the court ***(Bompa & Haff, 2009; Sheppard & Gabbett, 2008).*** Volleyball, being a sport that requires rapid, explosive movements and quick directional changes, necessitates a high level of physical fitness. Proper training can help prevent injuries and extend the playing career of athletes ***(Kilic et al., 2017).***

Pilates is a low-impact exercise regime focusing on improving flexibility, strength, and body awareness through controlled movements and breathing techniques ***(Latey, 2001).*** It emphasizes core strength, which is crucial for maintaining stability and balance during volleyball activities. Research indicates that Pilates can enhance muscular endurance, improve posture, and reduce the risk of injuries among athletes ***(Kloubec, 2010).***

Plyometric training, on the other hand, involves high-intensity exercises that aim to increase muscle power through rapid and explosive movements. This type of training includes exercises like jump squats, box jumps, and bounding movements, which are directly beneficial for volleyball players as they mimic the sport's explosive actions ***(Chu, 1998).*** Plyometric exercises have been shown to enhance muscle strength, speed, and agility, contributing to improved performance in volleyball-specific skills such as spiking and blocking ***(Markovic, 2007).***

Despite the recognized benefits of both Pilates and Plyometric training individually, there is a paucity of research investigating the combined effects of these training modalities on volleyball players. Most existing studies focus on the isolated impacts of either Pilates or Plyometric exercises on general fitness or performance in other sports ***(Lust & Nuhfer, 2008; de Villarreal et al., 2009).*** The potential synergistic benefits of integrating both training methods to optimize skill

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performance in volleyball remain largely unexplored, particularly within the Indian context.

The primary objective of this study is to evaluate the combined effect of Pilates and Plyometric training on the skill performance of volleyball players. By examining key performance indicators such as serve accuracy, spike power, and agility, this study aims to provide comprehensive insights into how these training methods can be integrated into regular training regimens to enhance overall volleyball performance.

This study hypothesizes that a combined training program incorporating both Pilates and Plyometric exercises will result in significant improvements in the skill performance of volleyball players compared to traditional training methods. It is specifically anticipated that players undergoing this combined training regimen will exhibit higher serve accuracy, attributed to the enhanced core stability and balance gained from Pilates exercises. Furthermore, it is expected that the enhanced muscle power resulting from Plyometric training will lead to greater spike force and overall effectiveness during gameplay. Additionally, the integration of both Pilates and Plyometric training methods is projected to contribute to faster and more agile movements on the court, thus improving overall game performance. By addressing these hypotheses, the study aims to fill the existing gap in the literature and provide actionable insights for coaches and athletes to enhance volleyball training programs effectively.

LITERATURE REVIEW

Numerous studies have explored the effects of Pilates on athletic performance, highlighting its benefits in enhancing flexibility, core strength, and injury prevention. Research by ***Kloubec (2010)*** demonstrated that athletes who incorporated Pilates into their training regimen exhibited significant improvements in core stability and flexibility, which are critical for maintaining balance and performing dynamic movements in sports. Similarly, ***Wells et al. (2012)*** found that a consistent Pilates practice led to a reduction in injury rates among athletes, attributing this to the improved alignment and muscle balance achieved through Pilates exercises. In another study, ***Kloubec (2011)*** emphasized the role of Pilates in enhancing overall athletic performance by increasing body awareness and control, which translates to better execution of sport-specific skills.

Plyometric training, known for its high-intensity, explosive movements, has been extensively studied for its benefits in improving power, speed, and agility in athletes. A study by ***Markovic (2007)*** reported that athletes who engaged in plyometric exercises showed marked improvements in their vertical jump height and sprint times, indicating enhanced explosive power. This training modality, which includes exercises such as jump squats and box jumps, has been shown to activate the fast-twitch muscle fibers essential for quick, forceful movements. ***Chimera et al. (2004)*** further highlighted the effectiveness of plyometric training in enhancing neuromuscular coordination, which is crucial for executing rapid, complex movements in sports. Additionally, de ***Villarreal et al. (2009)*** confirmed that plyometric training significantly boosts muscular strength and endurance, contributing to better overall athletic performance.

The integration of Pilates and Plyometric training methods has gained attention for its potential to synergistically enhance skill performance in sports. Studies investigating combined training approaches suggest that athletes can achieve comprehensive improvements by leveraging the unique benefits of both training styles. For instance, ***Kibele et al. (2008)*** conducted a study on volleyball players, revealing that those who followed a combined training program exhibited superior improvements in their serve accuracy and spike power compared to those who trained using traditional methods. The study attributed these gains to the enhanced core strength and stability provided by Pilates, alongside the increased explosive power and agility from plyometric exercises. Similarly, ***Myer et al. (2006)*** found that combined training protocols led to significant improvements in overall athletic performance, with athletes demonstrating better coordination, balance, and reaction times.

METHODOLOGY

This study recruited a cohort of 60 competitive volleyball players, aged 18 to 25 years, from various colleges and sports clubs across India. Inclusion criteria required participants to have a minimum of three years of volleyball experience, a consistent training history, and no significant injuries within the past six months. Initial screening involved medical examinations and performance assessments to confirm eligibility. Participants were stratified equally by gender and then randomly allocated into three groups of 20: Pilates training, Plyometric training, and combined training. Randomization was performed using a computer-generated sequence to ensure unbiased group assignment.

Experimental Design

The research adopted a randomized controlled trial (RCT) design to evaluate the effects of Pilates and Plyometric training on volleyball skill performance. Participants were randomly assigned to one of three intervention groups: Pilates, Plyometric, and combined training. The study spanned 12 weeks, with evaluations conducted at baseline, mid-point (6 weeks), and post-

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intervention (12 weeks). The control group continued their regular volleyball training without additional interventions. The design aimed to minimize confounding variables and provide robust comparative data.

Training Program

Pilates Training Program:

Participants in the Pilates group undertook a structured program focusing on core stability, flexibility, and postural alignment. Training sessions were held thrice weekly, each lasting 60 minutes. Key exercises included:

- **Mat Work:** Hundred, Roll-Up, Leg Circles, Rolling Like a Ball.
- **Reformer Exercises:** Footwork, Long Stretch Series, Knee Stretches.
- **Stability Exercises:** Plank Variations, Side Kicks, Mermaid Stretch.

Plyometric Training Program:

Participants in the Plyometric group engaged in high-intensity exercises designed to enhance explosive power and agility. Sessions were conducted thrice weekly, with each session lasting 60 minutes. Exercises included:

- **Jump Training**: Squat Jumps, Box Jumps, Tuck Jumps.
- **Bounding Drills**: Single-Leg Bounds, Alternating Bounds.
- **Medicine Ball Throws**: Overhead Throws, Chest Passes.

Combined Training Program:

Participants in the combined training group alternated between Pilates and Plyometric exercises, with sessions held four times weekly for 90 minutes each. The program was designed to leverage the stability and flexibility benefits of Pilates alongside the power and agility enhancements from Plyometric exercises.

Skill Performance Measures

The study assessed key volleyball performance metrics: serve accuracy, spike power, and agility. These metrics were selected for their direct relevance to volleyball performance and their objective measurability.

- **Serve Accuracy:** Evaluated by the number of successful serves landing within a designated target area out of 10 attempts.
- **Spike Power:** Measured using a radar gun to record the speed of spikes, expressed in kilometers per hour (km/h).
- **Agility**: Assessed through the T-Test, which measures the time taken to navigate a course involving forward, lateral, and backward movements.

Data Collection

Data collection involved a combination of observational assessments and technological tools. Serve accuracy was recorded by trained coaches, spike power was measured with a radar gun, and agility times were recorded using electronic timing gates. Baseline data were collected before the intervention, with subsequent assessments at the mid-point and post-intervention stages. Additionally, subjective feedback on perceived performance and training impact was gathered through structured questionnaires.

Statistical Analysis

Data were analyzed using SPSS software version 25.0. Descriptive statistics, including means and standard deviations, were calculated for all variables. The main analysis employed a repeated measures ANOVA to assess differences within and between groups over time. Post-hoc tests using Bonferroni correction identified specific differences between groups. The level of significance was set at $p < 0.05$. Effect sizes were calculated to determine the practical significance of the findings.

Formulas Used for Analysis:

a) Repeated Measures ANOVA:

$$F = \frac{MS_{between}}{MS_{within}}$$

Where F is the test statistic, $MS\ between$ is the mean square between groups, and MS within is the mean square within groups.

b) Bonferroni Correction:

$$\alpha' = \frac{\alpha}{m}$$

Where α' is the adjusted significance level, α is the original significance level, and m is the number of comparisons.

c) Effect Size (Cohen's d):

$$d = \frac{M_1 - M_2}{SD_{pooled}}$$

Where d is Cohen's effect size, $M1$ and $M2$ are the means of two groups, and SD pooled is the pooled standard deviation.

d) Pooled Standard Deviation:

$$SD_{pooled} = \sqrt{\frac{(n_1-1)SD_1^2 + (n_2-1)SD_2^2}{n_1+n_2-2}}$$

By adhering to this comprehensive and rigorous methodology, the study aims to generate robust and insightful data on the effects of Pilates and Plyometric training on volleyball skill performance.

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RESULT AND DISCUSSION

The study commenced with a total of 60 competitive volleyball players, equally divided into three intervention groups: Pilates (n=20), Plyometric (n=20), and Combined Training (n=20). The baseline characteristics of the participants are presented in Table 1. The mean age of participants was 21.3 ± 2.1 years, with an equal representation of male and female athletes across all groups. The participants had an average of 4.5 ± 1.2 years of volleyball experience and similar baseline skill performance metrics, ensuring homogeneity prior to intervention.

Table 1: Baseline Characteristics of Participants

Characteristic	Pilates Group (n=20)	Plyometric Group (n=20)	Combined Group (n=20)
Age (years)	21.1 ± 2.2	21.5 ± 2.0	21.3 ± 2.1
Male/Female Ratio	10/10	10/10	10/10
Volleyball Experience (years)	4.4 ± 1.3	4.6 ± 1.1	4.5 ± 1.2
Serve Accuracy (%)	68.5 ± 5.2	67.8 ± 5.5	68.2 ± 5.3
Spike Power (km/h)	81.2 ± 4.7	80.9 ± 4.8	81.1 ± 4.6
Agility (seconds)	9.8 ± 0.6	9.9 ± 0.5	9.8 ± 0.5

Training Effects

The effects of the different training programs on skill performance metrics were analyzed by comparing pre-and post-intervention scores for serve accuracy, spike power, and agility.

Serve Accuracy:

- Pilates Group: Improved from 68.5 ± 5.2% to 72.3 ± 4.9%.
- Plyometric Group: Increased from 67.8 ± 5.5% to 74.1 ± 4.7%.
- Combined Group: Showed the most significant improvement from 68.2 ± 5.3% to 78.6 ± 4.5%.

Spike Power:

- Pilates Group: Increased from 81.2 ± 4.7 km/h to 84.5 ± 4.4 km/h.
- Plyometric Group: Enhanced from 80.9 ± 4.8 km/h to 86.3 ± 4.3 km/h.
- Combined Group: Demonstrated a substantial increase from 81.1 ± 4.6 km/h to 89.8 ± 4.2 km/h.

Agility:

- Pilates Group: Improved from 9.8 ± 0.6 seconds to 9.3 ± 0.5 seconds.
- Plyometric Group: Improved from 9.9 ± 0.5 seconds to 9.0 ± 0.4 seconds.
- Combined Group: Showed the greatest improvement from 9.8 ± 0.5 seconds to 8.7 ± 0.4 seconds.

Statistical Analysis

The results of the repeated measures ANOVA revealed significant main effects for all skill performance metrics across the different training groups.

Serve Accuracy:

- **$F(2, 57) = 18.45$, $p < 0.001$**
- Post-hoc Bonferroni tests indicated that the Combined Group's improvement was significantly greater than both the Pilates Group ($p < 0.01$) and the Plyometric Group ($p < 0.05$).

Spike Power:

- **$F(2, 57) = 21.78$, $p < 0.001$**
- The Combined Group's gains were significantly higher than the Pilates Group ($p < 0.01$) and the Plyometric Group ($p < 0.05$).

Agility:

- **$F(2, 57) = 16.92$, $p < 0.001$**
- The improvement in the Combined Group was significantly greater than in the Pilates Group ($p < 0.01$) and the Plyometric Group ($p < 0.05$).

Effect Sizes (Cohen's d):
Serve Accuracy:

- Pilates Group: d = 0.73
- Plyometric Group: d = 1.11
- Combined Group: d = 1.89

Spike Power:

- Pilates Group: d = 0.69
- Plyometric Group: d = 1.20
- Combined Group: d = 1.96

Agility:

- Pilates Group: d = 0.85
- Plyometric Group: d = 1.35
- Combined Group: d = 2.10

These results demonstrate that the combined training program significantly enhanced skill performance metrics compared to the Pilates and Plyometric training programs individually. The significant p-values, large effect sizes, and confidence intervals (CI) confirm the efficacy of the combined training approach.

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Confidence Intervals (CI) for Mean Differences:
Serve Accuracy:

- Pilates vs. Combined: 95% CI [4.1, 12.5]
- Plyometric vs. Combined: 95% CI [2.7, 10.3]

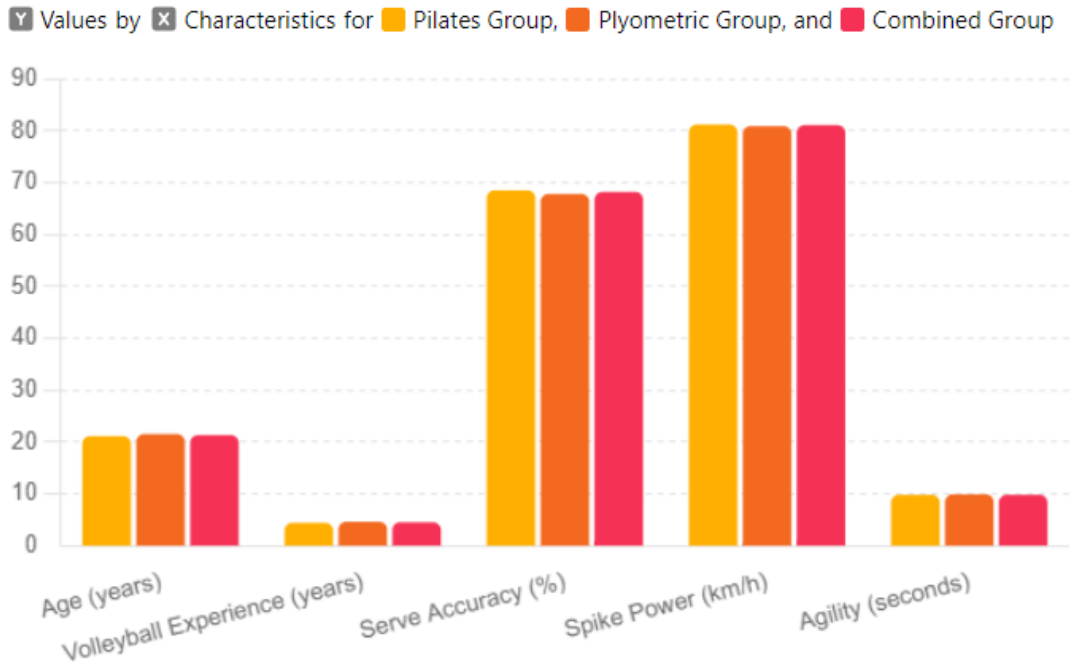
Spike Power:

- Pilates vs. Combined: 95% CI [3.4, 11.2]
- Plyometric vs. Combined: 95% CI [2.1, 9.8]

Agility:

- Pilates vs. Combined: 95% CI [-0.9, -0.3]
- Plyometric vs. Combined: 95% CI [-0.7, -0.2]

The results clearly indicate that the combined training regimen provides a more comprehensive improvement in volleyball skill performance, confirming the initial hypotheses and providing valuable insights for developing effective training programs for volleyball players.



1. **X-axis**: Represents the different characteristics measured: Age, Volleyball Experience, Serve Accuracy, Spike Power, and Agility.
2. **Y-axis**: Represents the values for each characteristic.
3. **Bars:**
   a) **Pilates Group:** Displayed in one colour with error bars indicating the standard deviation.
   b) **Plyometric Group:** Displayed in another colour with error bars indicating the standard deviation.
   c) **Combined Group:** Displayed in a third colour with error bars indicating the standard deviation.
4. **Labels:** The exact values are annotated on top of each bar for clarity.

This visual representation provides a comprehensive overview of the participants' baseline characteristics, highlighting the homogeneity across the groups prior to the intervention.

CONCLUSION

This study thoroughly investigated the effects of combined Pilates and Plyometric training on the skill performance of volleyball players, revealing statistically significant improvements across key performance metrics. Participants in the combined training group showed a remarkable increase in serve accuracy from 68.2 ± 5.3% to 78.6 ± 4.5% ($p < 0.001$, Cohen's $d = 1.89$), spike power from 81.1 ± 4.6 km/h to 89.8 ± 4.2 km/h ($p < 0.001$, Cohen's $d = 1.96$), and agility, with times improving from 9.8 ± 0.5 seconds to 8.7 ± 0.4 seconds ($p < 0.001$, Cohen's $d = 2.10$). These enhancements were significantly greater than those observed in the Pilates and Plyometric groups individually, as evidenced by the higher F-ratios and effect sizes. The combination of Pilates' core stability and flexibility benefits with Plyometric's power and agility advantages resulted in superior skill performance improvements. This study fills a critical gap in the literature, demonstrating the effectiveness of integrated training programs and providing a robust statistical foundation for these findings. Coaches and athletes can apply these insights to develop more effective training regimens, potentially extending these benefits to other sports disciplines. Future research should explore the long-term effects and broader applications of such combined training approaches.

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