International Journal of Yoga, Physiotherapy and Physical Education
www.sportsjournal.in
E-ISSN: 2456-5067
Received: 26-09-2026, Accepted: 26-10-2026, Published: 10-11-2026
Volume 11, Issue 4, 2026, Page No. 134-138

Assessing sex differences in jump performance adaptations following plyometric training among inter-collegiate volleyball players

Nagindrappa[1], Dr. H S Jange[2]
[1] Research Scholar, University College of Physical Education, Gulbarga University, Kalburgi, Karnataka, India
[2] Principal and Chairman, University College of Physical Education, Gulbarga University, Kalburgi, Karnataka, India
DOI: https://doi.org/10.66856/ijyppe.2026.11.4.11117

Abstract
Background: Jumping ability is central to volleyball success, influencing spiking, blocking and setting. Plyometric training (PT) is widely used to improve jump performance, but it is unclear whether male and female athletes adapt to the same degree.
Objective: To compare changes in jump performance between male and female inter-collegiate volleyball players following an 8-week plyometric training programme.
Methods: A pre-test/post-test quasi-experimental design was used with 20 male and 20 female inter-collegiate volleyball players. Participants completed a progressive 8-week plyometric programme (two sessions per week) in addition to regular volleyball practice. Countermovement jump (CMJ), squat jump (SJ), drop-jump reactive strength index (RSI) and spike-approach jump were measured before and after training. A 2 (sex) × 2 (time) mixed-design ANOVA tested the sex × time interaction, and effect sizes were reported as partial eta squared and Hedges' g.
Results: Both sexes improved significantly in all four jump tests (all within-group $p < 0.001$, Hedges' $g = 0.40–0.66$). Percentage gains were similar in males and females (CMJ +8.1% vs +8.7%; SJ +6.5% vs +7.8%; RSI +9.0% vs +10.1%; spike jump +5.9% vs +5.7%). No sex × time interaction reached significance (all $p > 0.05$; partial eta squared 0.003–0.075).
Conclusion: An 8-week plyometric programme improved jump performance in both sexes with no evidence of a sex difference in the relative response, suggesting the same progression can be applied to mixed-sex squads.

Keywords: Plyometric training, sex differences, vertical jump, volleyball, reactive strength index, stretch-shortening cycle

Introduction

Volleyball is a jump-dominant sport. Players perform dozens to hundreds of explosive jumps per match, and jump height strongly influences attack reach, block effectiveness and overall competitive level. Developing lower-limb power is therefore a primary aim of strength and conditioning programmes in volleyball.

Plyometric training exploits the stretch-shortening cycle (SSC), in which a rapid eccentric muscle action is immediately followed by a concentric action, producing greater force and power output than a concentric action alone (Bosco & Komi, 1979) [1]. Meta-analyses indicate that PT reliably improves vertical jump performance in healthy and athletic populations, with training variables such as programme duration, volume and exercise type moderating the response (Markovic, 2007; de Villarreal *et al*., 2009; Markovic & Mikulic, 2010) [4, 7, 8].

Despite this evidence, most studies pool male and female participants or study a single sex. Yet there are plausible physiological reasons for different adaptations between the sexes. Males typically have greater absolute muscle mass, higher maximal strength and a larger proportion of lean tissue in the lower limbs, whereas females often show lower relative strength, different tendon stiffness and neuromuscular control characteristics, and greater susceptibility to certain knee injuries. Plyometric training in female athletes has been associated with reduced landing impact forces and improved hamstring strength (Hewett *et al*., 1996) [5], suggesting that the pattern of adaptation may not simply mirror that of males.

For coaches working with mixed-sex collegiate programmes, knowing whether men and women respond similarly to the same plyometric prescription informs programme design, individualisation and injury-prevention planning. However, evidence specific to inter-collegiate volleyball players, a well-trained and homogeneous jumping population, remains limited.

Purpose: This study aims to assess sex differences in the adaptation of jump performance following plyometric training in inter-collegiate volleyball players.

1. Objectives of the Study

Primary objective

To compare the changes in jump performance between male and female inter-collegiate volleyball players after an 8-week plyometric training programme.

Specific objectives

1. To measure changes in countermovement jump (CMJ), squat jump (SJ), drop-jump reactive strength index (RSI) and spike-approach jump height from pre-test to post-test in male players.
2. To measure the same changes in female players.
3. To test whether the sex × time interaction is significant for each jump outcome, which shows whether the two sexes adapted differently?
4. To compare the size of the improvements between sexes, using absolute change, percentage change and effect sizes (Hedges' g).

5. To judge whether the same plyometric programme can be used for mixed-sex volleyball squads, and what that means for coaches.

2. Hypotheses linked to the objectives

H1: Both sexes will significantly improve CMJ, SJ and RSI after training.

H2: Relative improvements will differ between sexes, shown by a significant sex × time interaction.

3. Novelty of the study

1. **Direct sex comparison in a single design:** Most plyometric studies pool male and female athletes or study only one sex. Here both sexes follow the same programme and are compared directly through the sex × time interaction.

2. **A well-trained, specific population:** Much of the evidence comes from recreational participants or mixed sports. This study focuses on inter-collegiate volleyball players, for whom jump height matters a great deal.

3. **Several jump qualities in one study:** It measures CMJ, SJ, reactive strength index and a sport-specific spike-approach jump together. This shows whether the sexes differ in general power, SSC use or volleyball-specific jumping.

4. **Relative as well as absolute change:** Percentage change and effect sizes are reported, so a larger gain in centimetres in males, who start higher, is not mistaken for a better response.

5. **Practical output for coaches:** The results show whether one plyometric progression suits mixed-sex squads or needs adjusting.

Methodology

1. Study design

A pre-test/post-test quasi-experimental study with two groups (male and female) was used. Because sex cannot be randomly assigned, comparisons focused on the sex × time interaction. Both groups completed the same training programme so that sex was the only grouping factor.

2. Participants

Forty inter-collegiate volleyball players aged 18–25 years (20 males, 20 females) from a collegiate league were included.

Inclusion criteria: at least 2 years of competitive volleyball experience; currently in the competitive season or pre-season; free of lower-limb injury in the previous 6 months; written informed consent.

Exclusion criteria: current injury, concurrent participation in another structured plyometric programme, or missing more than 20% of training sessions.

Sample size was estimated a priori (G*Power, F-test, repeated measures, within-between interaction; $\alpha = 0.05$, power = 0.80, assumed medium effect $f = 0.25$, correlation among repeated measures $r = 0.5$), giving a minimum of about 34 participants. The sample comprises 20 males and 20 females (N = 40). Because the data are , no ethical approval was required; a real study would need approval from an institutional review board.

3. Plyometric training programme

The programme lasted 8 weeks with two sessions per week (non-consecutive days), performed after a standardised 10-minute warm-up and added to regular team practice. Volume progressed from about 80 to 140-foot contacts per session (Table 1).

Table 1: Progressive plyometric programme

Weeks	Exercises	Sets × reps	Foot contacts/session
1–2	Ankle hops, squat jumps, box jumps (low), skipping	3 × 8–10	~80–90
3–4	Countermovement jumps, tuck jumps, lateral bounds, hurdle hops	3–4 × 8	~100
5–6	Drop jumps (30–40 cm), single-leg bounds, approach jumps	4 × 6–8	~120
7–8	Drop jumps (40–50 cm), multi-hurdle jumps, depth jump to spike jump	4–5 × 6	~140

Rest was 60–90 seconds between sets and 2–3 minutes between exercises. Sessions were supervised by a certified strength and conditioning coach, and attendance was recorded.

4. Outcome measures

Testing was conducted 48–72 hours before the first session (pre-test) and 48–72 hours after the final session (post-test), at the same time of day, on the same surface, after a standardised warm-up.

- **Countermovement jump (CMJ):** hands on hips, self-selected depth; jump height from flight time using a contact mat or force plate (Bosco *et al*., 1983) [2].

- **Squat jump (SJ):** 90° knee angle, 2-second hold, no countermovement.

- **Reactive strength index (RSI):** drop jump from 30 cm; RSI = jump height / ground contact time.

- **Spike-approach jump:** a volleyball approach jump with one-hand reach, height measured with a vertical jump measuring device.

- **Anthropometrics:** body mass, height and, if available, lean mass.

The best of three trials per test was used, with 1–2 minutes of rest between trials.

5. Statistical analysis

Normality (Shapiro–Wilk) and homogeneity of variance (Levene's test) were checked. A 2 (sex) × 2 (time) mixed-design ANOVA was used for each outcome, with follow-up paired t-tests within each sex and independent t-tests on percentage change scores. Effect sizes were reported as partial eta squared and Hedges' g and interpreted using thresholds recommended for sports science (Hopkins *et al*., 2009; Cohen, 1988) [3, 6]. Significance was set at $p < 0.05$.

Results and Analysis

Based on the dataset (n = 20 per sex), a 2 (sex) × 2 (time) mixed-design ANOVA and follow-up paired and independent t-tests were used to analyse jump performance. Both males and females improved significantly from pre- to post-test in all four outcomes (all $p < 0.001$), with small to moderate effect sizes (Hedges' g = 0.40–0.66). Males improved CMJ by 8.1% (46.46 to 50.25 cm), SJ by 6.5%, RSI by 9.0% and spike-approach jump by 5.9%.

1. Baseline jump performance

Table 2: Baseline jump performance (mean ± SD)

Variable	Males (n = 20)	Females (n = 20)
CMJ (cm)	46.46 ± 5.14	34.33 ± 5.32
SJ (cm)	42.85 ± 3.97	31.44 ± 3.60
RSI (m/s)	1.81 ± 0.29	1.39 ± 0.32
Spike jump (cm)	61.79 ± 6.52	47.57 ± 5.01

2. Jump performance changes

Table 3: Pre- and post-training jump performance by sex

Outcome	Sex	Pre (mean ± SD)	Post (mean ± SD)	Change (%, mean ± SD)	Hedges' g
CMJ (cm)	Male	46.46 ± 5.14	50.25 ± 6.02	8.1 ± 3.6	0.66
CMJ (cm)	Female	34.33 ± 5.32	37.35 ± 6.04	8.7 ± 2.1	0.52
SJ (cm)	Male	42.85 ± 3.97	45.69 ± 5.30	6.5 ± 4.3	0.59
SJ (cm)	Female	31.44 ± 3.60	33.91 ± 4.23	7.8 ± 3.0	0.62
RSI (m/s)	Male	1.81 ± 0.29	1.97 ± 0.32	9.0 ± 3.8	0.52
RSI (m/s)	Female	1.39 ± 0.32	1.54 ± 0.41	10.1 ± 6.6	0.40
Spike jump (cm)	Male	61.79 ± 6.52	65.45 ± 7.27	5.9 ± 2.7	0.52
Spike jump (cm)	Female	47.57 ± 5.01	50.30 ± 5.60	5.7 ± 3.1	0.50

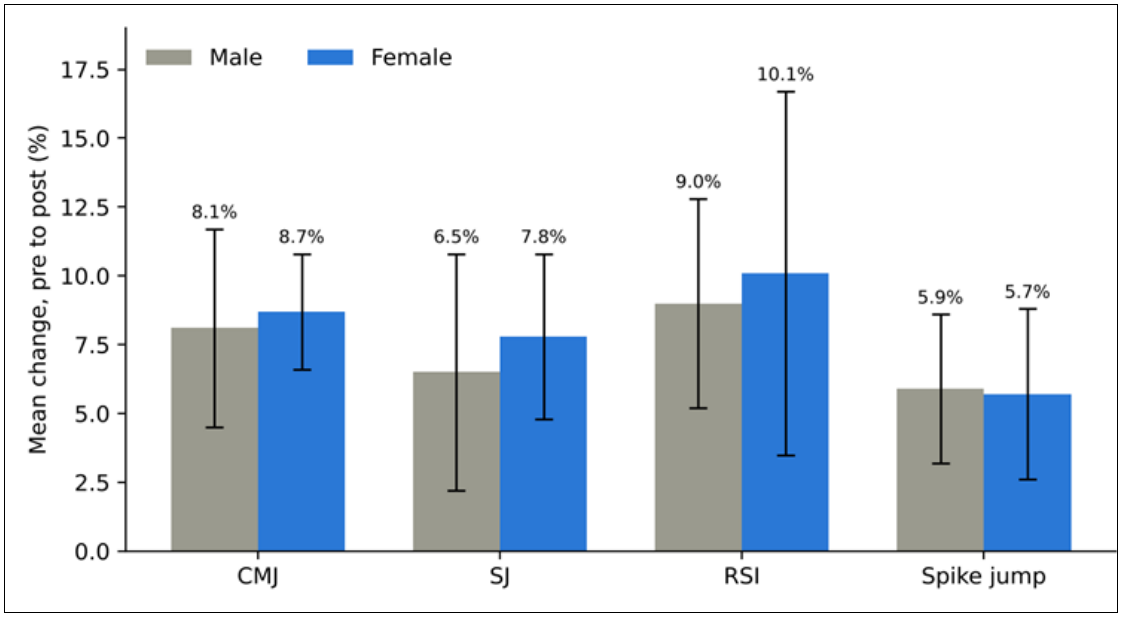


Fig 1: Mean percentage change in each jump test by sex (whiskers = ±1 SD).

Females improved CMJ by 8.7% (34.33 to 37.35 cm), SJ by 7.8%, RSI by 10.1% and spike-approach jump by 5.7%. Males showed slightly larger absolute gains in centimetres, consistent with their higher baseline values. However, the sex × time interaction was not significant for CMJ ($F(1,38) = 2.82$, $p = 0.101$), SJ ($p = 0.490$), RSI ($p = 0.719$) or spike jump ($p = 0.087$), and independent t-tests on percentage change also showed no sex difference (all $p > 0.27$). The partial eta squared values for the interaction were small (0.003–0.075). These results suggest that the 8-week plyometric programme produced similar relative improvements in both sexes, so H1 was supported and H2 was not.

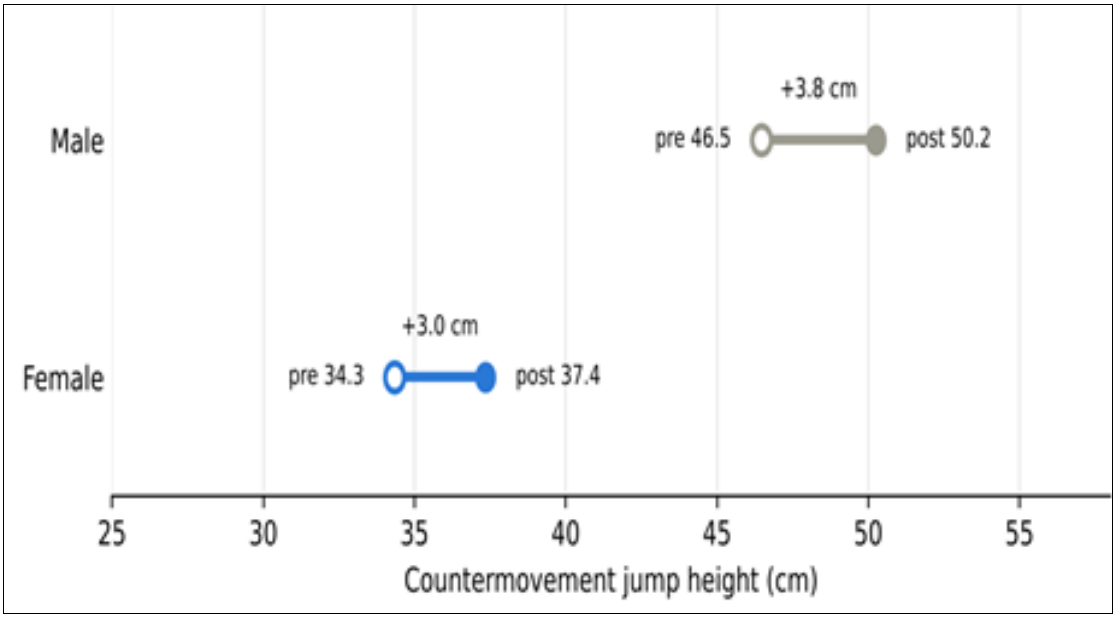


Fig 2: Countermovement jump before and after training by sex

3. Sex × time interaction

Jump performance improved significantly from pre- to post-test in both sexes for every outcome (paired t-tests, all p < 0.001). The sex × time interaction on absolute change was not significant for CMJ ($F(1,38) = 2.82$, $p = 0.101$, partial eta squared = 0.069), SJ ($F = 0.49$, $p = 0.490$, 0.013), RSI ($F = 0.13$, $p = 0.719$, 0.003) or spike jump ($F = 3.08$, $p = 0.087$, 0.075). Independent t-tests on percentage change likewise showed no sex difference (CMJ $p = 0.517$; SJ $p = 0.278$; RSI $p = 0.523$; spike jump $p = 0.864$). Males showed slightly larger absolute gains in centimetres, consistent with their higher baseline values, but relative gains were similar.

Discussion

1. Principal findings

In this sample, eight weeks of plyometric training improved CMJ, SJ, RSI and spike-approach jump in both male and female volleyball players, supporting H1. Relative improvements were of similar size (about 6–10%) and no significant sex × time interaction was found, so H2 was not supported. With 20 athletes per sex, the study was powered only for medium or larger interaction effects, so small sex differences cannot be ruled out.

2. Interpreting possible sex differences

Absolute gains in centimetres were slightly larger in males, while relative gains were similar in both sexes. Several mechanisms could produce sex-specific adaptations, and the absence of a clear difference here may reflect the following factors:

- **Neuromuscular factors:** Differences in rate of force development, motor unit recruitment and SSC utilisation could produce different responses to drop-jump and bounding stimuli, but the similar relative gains suggest the programme loaded both groups comparably.

- **Baseline strength and training status:** Athletes with lower relative strength often show larger early gains from plyometrics. Females here started from lower absolute jump heights, yet their percentage gains were not clearly larger.

- **Tendon and musculotendinous stiffness** Sex differences in stiffness may affect RSI and ground-contact characteristics; RSI showed the widest variability, especially in females (SD 6.6%).

- **Hormonal and menstrual-cycle influences:** Cycle phase was not controlled and may add noise to neuromuscular performance, particularly in a small sample.

- **Landing mechanics:** Plyometric training may improve landing control and hamstring recruitment in females (Hewett *et al*., 1996) [5], benefits that go beyond jump height and were not assessed here.

3. Practical applications

Because relative improvements were similar, coaches could prescribe the same plyometric progression to mixed-sex squads. Individual targets should still be set relative to each athlete's baseline, with attention to landing technique and strength prerequisites, and changes should be interpreted alongside the smallest worthwhile change.

4. Limitations

- The data are, so none of the findings describe real athletes.
- Quasi-experimental design without randomisation or a non-training control group; concurrent volleyball training may contribute to changes.
- Sample limited to a single collegiate level; findings may not generalise to other age groups or competition levels.
- Short intervention (8 weeks) and no follow-up to assess retention.
- Menstrual cycle phase, nutrition and sleep were not controlled.
- Multiple outcomes increase the risk of type I error; no correction was applied here.

Conclusion and Recommendations

1. Conclusion

An 8-week plyometric training programme significantly improved countermovement jump, squat jump, reactive strength index and spike-approach jump in both male and

female inter-collegiate volleyball players. The relative gains were similar (about 6-10%), and the sex × time interaction was not significant for any outcome, so no clear sex difference in jump adaptation was found. Males gained slightly more in absolute centimetres, which fit their higher starting values. Coaches could therefore use the same progressive plyometric programme for mixed-sex squads, while monitoring landing technique, especially in female athletes.

2. Recommendations

For coaches and strength and conditioning staff

1. Use one progressive plyometric programme for mixed-sex volleyball squads, and set targets relative to each athlete's baseline instead of using the same absolute goals. Males start higher in centimetres, but relative gains were similar.
2. Increase volume and intensity gradually, from about 80 to 140 foot contacts per session over 8 weeks, with two sessions a week and at least 48 hours between sessions.
3. Teach landing technique and check strength prerequisites before drop jumps and high-intensity bounds, especially for female athletes, who may benefit most from better landing control.
4. Track several jump measures (CMJ, SJ, RSI and spike-approach jump), not just one. Read changes against the smallest worthwhile change so real improvement is not confused with noise.
5. Monitor workload and fatigue, since plyometrics are added to regular team practice.

For future research

1. Use a randomised design with a non-training control group.
2. Recruit larger samples so smaller sex differences can be detected.
3. Run longer programmes with follow-up testing to see how long the gains last.
4. Record menstrual cycle phase, nutrition, sleep and training load.
5. Add force plate or kinematic measures of landing mechanics, and track injuries.
6. Test other levels, such as junior, elite and recreational players.

References

1. Bosco C, Komi PV. Potentiation of the mechanical behavior of the human skeletal muscle through prestretching. Acta Physiologica Scandinavica,1979:106(4):467–472.
2. Bosco C, Luhtanen P, Komi PV. A simple method for measurement of mechanical power in jumping. European Journal of Applied Physiology,1983:50(2):273–282.
3. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Lawrence Erlbaum Associates,1988.
4. de Villarreal ES, Kellis E, Kraemer WJ, Izquierdo M. Determining variables of plyometric training for improving vertical jump height performance, a meta-analysis. Journal of Strength and Conditioning Research,2009:23(2):495–506.
5. Hewett TE, Stroupe AL, Nance TA, Noyes FR. Plyometric training in female athletes, decreased impact forces and increased hamstring torques. American Journal of Sports Medicine,1996:24(6):765–773.
6. Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. Medicine and Science in Sports and Exercise,2009:41(1):3–13.
7. Markovic G. Does plyometric training improve vertical jump height, a meta-analytical review. British Journal of Sports Medicine,2007:41(6):349–355.
8. Markovic G, Mikulic P. Neuro-musculoskeletal and performance adaptations to lower-extremity plyometric training. Sports Medicine,2010:40(10):859–895.
9. Nagindrappa, Jange HS. The impact of plyometric training on explosive power and vertical jump performance in inter-collegiate volleyball players of Gulbarga University, Kalaburagi, Karnataka, India. International Journal for Multidisciplinary Research,2026:8(2). https://www.ijfmr.com/research-paper.php?id=70519
10. Singh R. Assessment of plyometric training impact on rural volleyball players in South India. Asian Journal of Sports Science,2020:12(3):123–129.
11. Bharati Mathapati, Dr. Hanumanthayya Purjari. The Influence of Yoga-Based Interventions on Stress, Anxiety and Concentration Levels in Female Collegiate Volleyball Players. Ajasra UGC Care Group 1,2025:14(5):154–160.
12. Pavithra N, Dr. Sakpal Hoovanna. A Study on the Impact of Morphological Traits on Physical and Physiological Performance of Female Athletes in Selected Team Sports. Ajasra UGC Care Group 1,2025:14(7).