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Differential Impacts of a Four-Week Plyometric Training Intervention on Vertical Jump Performance across Basketball, Hockey, and Volleyball Athletes

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Abstract: Introduction: Explosive lower-limb power, frequently assessed through vertical jump height, is a crucial determinant of performance in team sports. Plyometric training enhances neuromuscular efficiency and jump performance; however, sport-specific responses to short-term interventions remain insufficiently studied. This research examined the effects of a four-week plyometric training program on vertical jump performance in inter-university basketball, hockey, and volleyball athletes from LNIPE Gwalior and LNIPE NERC.

Objective: To evaluate and compare sport-specific improvements in vertical jump height following a standardized four-week plyometric training program in basketball, hockey, and volleyball athletes.

Methods: Forty-five male inter-university athletes (n = 15 per sport) aged 18–25 years participated. Vertical jump height was measured manually using the chalk-mark technique pre- and post-intervention. All athletes completed an identical plyometric program (three sessions/week). Data were analyzed using a two-way mixed ANOVA with Bonferroni-adjusted post-hoc tests.

Results: Significant main effects were found for time ($F(1, 42) = 376.21$, $p < 0.001$, $\eta^2_p = 0.90$) and sport ($F(2, 42) = 19.84$, $p < 0.001$, $\eta^2_p = 0.49$), along with a significant interaction ($F(2, 42) = 12.56$, $p < 0.001$, $\eta^2_p = 0.37$). Volleyball athletes improved significantly more than basketball ($p = 0.042$) and hockey ($p < 0.001$) athletes, while basketball athletes improved more than hockey ($p = 0.018$).

Conclusion: Four weeks of plyometric training significantly enhanced vertical jump performance in all groups, with volleyball athletes showing the greatest gains, followed by basketball and hockey athletes. Sport-specific demands and baseline plyometric exposure likely influenced the observed differences.

Keywords: Plyometric training, vertical jump, explosive strength, team sports, sport-specific adaptation.

I. INTRODUCTION

Explosive lower-limb power plays a pivotal role in the success of athletes across a range of team sports, influencing skills such as sprint acceleration, rapid directional changes, and vertical jump height. Among these, the vertical jump is widely recognized as a reliable indicator of lower-body explosive strength and neuromuscular performance. In sports such as basketball, hockey, and volleyball, vertical jump capability is not only essential for sport-specific actions—such as rebounding and blocking in basketball, intercepting and aerial challenges in hockey, and spiking and blocking in volleyball—but also reflects the overall power and conditioning status of the athlete. Plyometric training, characterized by rapid stretch–shortening cycle (SSC) movements, has been extensively documented as an effective method to enhance vertical jump performance. Through exercises like depth jumps, bounding, and box jumps, plyometric protocols stimulate neuromuscular adaptations, increase motor unit recruitment, and improve the efficiency of force production. While several studies have investigated the benefits of plyometric training in single-sport contexts, there remains a gap in understanding sport-specific responses when identical training interventions are applied across athletes from different sporting backgrounds.

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The biomechanical demands, movement patterns, and frequency of explosive actions vary considerably between basketball, hockey, and volleyball, which may lead to differentiated adaptation profiles. The present study addresses this gap by examining the sport-specific responses to a standardized four-week plyometric training program in inter-university level athletes drawn from Lakshmibai National Institute of Physical Education (LNIPE), Gwalior and LNIPE North East Regional Centre (NERC).

These participants represent a high-performance cohort, actively competing at the inter-university level and meeting rigorous selection criteria. By evaluating pre- and post-intervention changes in vertical jump performance, this research aims to determine whether short-term plyometric training yields differential improvements across basketball, hockey, and volleyball athletes. It is hypothesized that all three groups will demonstrate significant gains in vertical jump performance following the intervention, with volleyball athletes potentially showing the greatest relative improvement due to the inherently high plyometric demands of their sport. The findings are expected to provide valuable insights for strength and conditioning professionals in designing sport-specific explosive training programs for competitive university athletes.

II. METHODS

This study employed a pre-test–post-test experimental design with three parallel sport-specific groups: basketball, hockey, and volleyball. All participants completed the same four-week plyometric training intervention, with vertical jump performance measured before and after the program. The study was conducted at Lakshmibai National Institute of Physical Education (LNIPE), Gwalior, and LNIPE North East Regional Centre (NERC), under controlled training and testing conditions.

A total of 45 male inter-university athletes (15 basketball, 15 hockey, and 15 volleyball) aged 18–25 years, each with a minimum of two years of competitive experience in their respective sports and actively training for inter-university tournaments, participated in the study. Inclusion criteria required participants to be registered inter-university players from LNIPE Gwalior or LNIPE NERC, free from any lower-limb injury in the past six months, and without prior structured plyometric training within the last month. Athletes with a history of chronic musculoskeletal disorders or those currently engaged in conflicting high-intensity training programs were excluded.

A. Training Intervention

The plyometric program lasted four weeks, wit h three sessions per week on non-consecutive days. All sessions were supervised by certified strength and conditioning coaches.

B. General Structure Per session

1) Warm-up (10 minutes) – Dynamic stretches, mobility drills, and low-intensity running.
2) Main plyometric block (25–30 minutes) – Sport-independent exercises targeting vertical and horizontal force production.
3) Cool-down (5–10 minutes) – Static stretching and relaxation techniques.

Table 1. Four-Week Plyometric Training Plan

Week	Exercise	Sets	Reps	Rest Between Sets	Notes
1	Squat Jumps	3	10	90 sec	Bodyweight
	Lateral Bounds	3	8/leg	90 sec	Controlled landing
	Depth Jumps (30 cm)	3	8	2 min	Minimize ground contact
	Box Jumps (40 cm)	3	8	90 sec	
2	Squat Jumps	4	10	90 sec	Add light load (2–5 kg)
	Lateral Bounds	4	8/leg	90 sec	
	Depth Jumps (40 cm)	3	8	2 min	
	Box Jumps (50 cm)	3	8	90 sec	
3	Tuck Jumps	4	10	90 sec	Max height
	Lateral Bounds	4	10/leg	90 sec	
	Depth Jumps (45 cm)	4	8	2 min	

Week	Exercise	Sets	Reps	Rest Between Sets	Notes
	Single-Leg Hops	3	8/leg	90 sec	Balance focus
4	Tuck Jumps	4	12	90 sec	
	Lateral Bounds	4	10/leg	90 sec	
	Depth Jumps (50 cm)	4	8	2 min	
	Broad Jumps	3	8	90 sec	Max horizontal distance

Vertical jump height was measured using a manual method with a wall-mounted vertical jump measuring scale (e.g., Vertec or marked wall and chalk technique). Participants applied chalk to the fingertips of their dominant hand and stood side-on to the measuring surface, reaching upward to mark their standing reach height. They then performed a maximal countermovement jump (CMJ), attempting to touch as high as possible on the wall. The difference between the standing reach height and the highest jump mark was recorded as the vertical jump height in centimeters. Each athlete completed three trials, with the best attempt used for analysis, and a standardized rest period of two minutes was provided between trials.

All statistical analyses were performed using SPSS. Data were tested for normality using the Shapiro–Wilk test. A two-way mixed ANOVA was used to analyze the interaction between time (pre, post) and sport type (basketball, hockey, volleyball). Where significant interactions were found, Bonferroni-adjusted post-hoc tests were conducted. Partial eta squared (η^2) was calculated as a measure of effect size. Statistical significance was set at $p < 0.05$.

III. RESULTS

A total of 45 male inter-university athletes participated in the study, with 15 athletes in each sport group: basketball, hockey, and volleyball. The mean (± SD) vertical jump (VJ) height for each sport pre- and post-intervention is presented in Table 2. All three groups demonstrated an improvement in vertical jump height after the four-week plyometric training program. Volleyball athletes recorded the highest mean improvement (5.02 ± 0.97 cm), followed by basketball athletes (4.47 ± 0.83 cm) and hockey athletes (3.11 ± 0.89 cm).

Table 2. Mean (± SD) Vertical Jump Height (cm) Pre- and Post-Intervention

Sport	Pre VJ Height (cm)	Post VJ Height (cm)	Mean Change (cm)
Basketball	47.98 ± 2.20	52.45 ± 2.16	4.47 ± 0.83
Hockey	48.23 ± 2.10	51.34 ± 2.05	3.11 ± 0.89
Volleyball	52.11 ± 2.24	57.13 ± 2.18	5.02 ± 0.97

A two-way mixed ANOVA was conducted to examine the effect of time (pre-test vs post-test) and sport (basketball, hockey, volleyball) on vertical jump height.

Table 3 presents the ANOVA summary for the main effects and the interaction effect.

Table 3. Two-Way Mixed ANOVA for Vertical Jump Height

Effect	df	F	p-value	Partial η^2
Time	1, 42	376.21	< 0.001	0.90
Sport	2, 42	19.84	< 0.001	0.49
Time × Sport	2, 42	12.56	< 0.001	0.37

The two-way mixed ANOVA revealed a statistically significant main effect of time ($F(1, 42) = 376.21$, $p < 0.001$, $\eta^2_p = 0.90$), indicating that vertical jump height increased significantly from pre-test to post-test across all three sports. A significant main effect of sport was also observed ($F(2, 42) = 19.84$, $p < 0.001$, $\eta^2_p = 0.49$), showing that vertical jump performance differed among basketball, hockey, and volleyball athletes when averaging across time points. Furthermore, the interaction effect between time and sport was statistically significant ($F(2, 42) = 12.56$, $p < 0.001$, $\eta^2_p = 0.37$), suggesting that the degree of improvement in vertical jump height varied depending on the sport.

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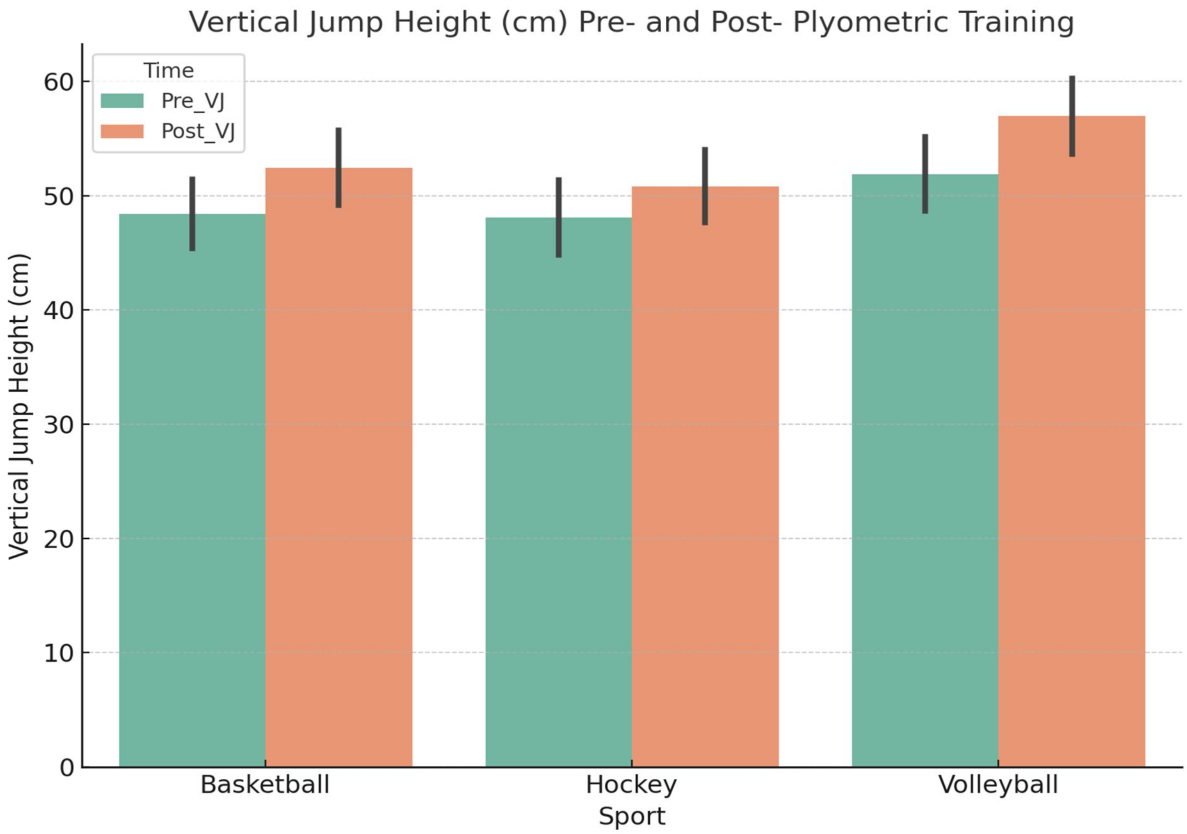
Post-hoc analysis with Bonferroni correction indicated that volleyball athletes improved significantly more than both basketball (p = 0.042) and hockey athletes ($p < 0.001$), while basketball athletes demonstrated significantly greater improvement compared to hockey athletes (p = 0.018). These findings highlight that although plyometric training was effective across all sports, volleyball players experienced the greatest gains in vertical jump height, followed by basketball and then hockey athletes.

Graph 1



The bar graph 1 shows that all three sports experienced an increase in vertical jump height after the four-week plyometric training program, with volleyball athletes showing the largest improvement, followed by basketball, and then hockey. This visual trend aligns with the statistical results, where the significant Time × Sport interaction indicated sport-specific differences in improvement magnitude.

IV. DISCUSSION

The present study examined sport-specific responses to a four-week plyometric training intervention on vertical jump performance among inter-university basketball, hockey, and volleyball athletes from LNIPE Gwalior and LNIPE NERC. The main findings indicated that all three sports demonstrated significant improvements in vertical jump height following the intervention, with volleyball athletes achieving the greatest gains, followed by basketball and hockey athletes. These results confirm the effectiveness of short-term plyometric training in enhancing explosive lower-body performance while also revealing distinct sport-specific adaptation patterns.

The significant main effect of time supports previous literature indicating that plyometric exercises, by enhancing the stretch–shortening cycle efficiency, lead to notable improvements in vertical jump performance even in a relatively short duration of four weeks. Similar improvements have been reported in various sports contexts, where increases in motor unit recruitment, rate of force development, and muscle–tendon stiffness contribute to enhanced jump height. The significant main effect of sport suggests inherent differences in vertical jump capability across basketball, hockey, and volleyball athletes, independent of the intervention. These differences may stem from the varying biomechanical and tactical demands of each sport.

Volleyball players regularly engage in high-frequency vertical jumps during spikes and blocks, while basketball players perform frequent jumps for rebounding and shooting. In contrast, hockey involves less frequent vertical jump actions, with a greater emphasis on horizontal acceleration and agility, potentially explaining the lower baseline and smaller improvement in this group.The significant interaction effect further highlights that the magnitude of improvement was influenced by the sport-specific demands and prior neuromuscular adaptation. The largest improvement in volleyball athletes may be attributed to the high transferability of plyometric drills to the explosive actions required in their sport. Basketball players also benefited considerably, though to a lesser degree, while hockey players exhibited more modest gains, possibly due to differences in movement specificity and neuromuscular recruitment patterns.

The post-hoc results reinforce these findings, showing that volleyball players improved significantly more than both basketball and hockey athletes, and basketball players improved more than hockey players. This ranking underscores the role of sport-specific movement patterns and baseline plyometric conditioning in mediating training outcomes.

Overall, the findings of this study suggest that while plyometric training is universally beneficial for explosive lower-limb power, tailoring exercise selection and volume to the demands of each sport may yield even greater performance benefits. For sports such as hockey, incorporating more horizontal and multidirectional plyometric elements might enhance transferability to match-play performance.

V. CONCLUSION

This study demonstrated that a four-week plyometric training program significantly improved vertical jump performance in inter-university basketball, hockey, and volleyball athletes from LNIPE Gwalior and LNIPE NERC. While all groups benefited from the intervention, volleyball athletes exhibited the greatest gains in vertical jump height, followed by basketball and hockey athletes. These results reflect the influence of sport-specific movement demands and neuromuscular adaptations on training outcomes. The findings confirm the efficacy of short-term plyometric training for enhancing explosive lower-limb power and highlight the importance of tailoring training content to the specific biomechanical requirements of each sport.

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