

A multivariate regression analysis of a comprehensive rehabilitation program and performance improvement in young female volleyball players

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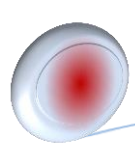
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Abstract

Purpose: This study aimed to investigate the efficacy of a comprehensive rehabilitation program tailored for college female volleyball players in India, specifically focusing on its impact on vertical jump performance.

Material and Methods: Twenty-seven female college volleyball players participated in the study, undergoing a preseason rehabilitation program comprising various exercises targeting strength, power, stability, agility, and flexibility. Pre- and post-rehabilitation assessments were conducted to evaluate changes in vertical jump height using a Vertec vertical jump measuring device. Statistical analysis included multivariate regression analysis and paired t-tests.



Results: The multivariate regression analysis revealed significant positive associations between several rehabilitation components, including squats, depth jumps, and plyometric circuits, and improved vertical jump height ($p < 0.01$). Paired t-test results indicated a significant increase in vertical jump height post-rehabilitation ($p < 0.0001$), with a mean difference of 4.863 cm. Strong positive correlations were observed between baseline and post-rehabilitation vertical jump measurements ($r = 0.9629$).

Conclusions: The findings demonstrate the effectiveness of the comprehensive rehabilitation program in enhancing vertical jump performance among college female volleyball players in India. By targeting multiple facets of physical fitness and movement quality, the program facilitated significant improvements in explosive lower body strength and power, essential for volleyball performance. These results underscore the importance of tailored rehabilitation interventions in optimizing athlete capabilities and achieving success on the volleyball court.

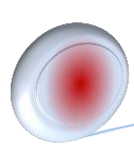
Keywords: Volleyball, rehabilitation program, vertical jump height, female athletes, performance enhancement.

Introduction

Competitive volleyball demands a unique blend of physical prowess, encompassing traits like strength, power, agility, and endurance (Palani et al., 2024). Athletes in this demanding sport often grapple with injuries and performance constraints, making effective rehabilitation strategies imperative to surmount these hurdles. In the realm of collegiate female volleyball in India, the quest for excellence is not only about triumphing on the court but also entails safeguarding athletes' well-being. Thus, understanding the efficacy of rehabilitation programs in fostering performance enhancement assumes paramount importance (Rousanoglou et al., 2008; Giatsis., 2023). Against this backdrop, this study embarks on a journey to probe the efficacy of a comprehensive rehabilitation program tailored for college female volleyball players in India (Miguel-Ortega et al.,

2023). The focal point lies in elucidating how such an intervention impacts performance metrics, particularly vertical jump height. This inquiry is not merely an academic pursuit but a practical endeavor aimed at unraveling insights that can transform training regimes and augment athletes' capabilities while mitigating injury risks (Dalrymple et al., 2010; Papadopoulou., 2020).

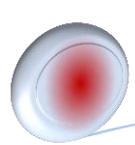
Volleyball, with its rapid transitions between explosive jumps, quick directional changes, and sustained periods of physical exertion, places immense strain on the body. Consequently, injuries, ranging from sprains to overuse ailments, frequently afflict players (Ibrahim., 2022). However, beyond the immediate concern of injury mitigation, lies the broader ambition of optimizing athletic performance. It is in this vein that the concept of rehabilitation assumes significance, transcending the



traditional notion of recuperating from injuries to encompass a proactive approach toward enhancing physical abilities (Giarda et al., 2024; Alvares et al., 2023).

Central to our investigation is the concept of a comprehensive rehabilitation program – a holistic regimen that transcends the mere alleviation of injury symptoms to encompass a multifaceted approach aimed at fortifying the athlete's physical foundation. By integrating diverse components targeting strength, power, stability, agility, and flexibility, this rehabilitation paradigm seeks to fortify athletes against the rigors of competitive play, thereby enhancing their overall performance trajectory (Marotta et al., 2023; Dischiavi et al., 2023). In the context of college female volleyball players in India, where the pursuit of excellence is fueled by passion and ambition, the need for evidence-based interventions is pronounced. It is against this backdrop that this study endeavors to fill a crucial gap in the existing literature by empirically examining the impact of a comprehensive rehabilitation program (Parpa & Michaelides., 2022; Chantrelle et al., 2022). By scrutinizing how various rehabilitation components correlate with performance metrics, such as vertical jump height, we aspire to furnish actionable insights that can inform coaching practices, training protocols, and injury prevention

strategies within the collegiate volleyball domain (Taylor et al., 2022). The significance of this study extends beyond the confines of academia, resonating deeply with stakeholders across the sporting spectrum. Coaches, trainers, sports medicine practitioners, and athletes themselves stand to benefit from a deeper understanding of the interplay between rehabilitation interventions and performance outcomes. Armed with empirical evidence, practitioners can refine their approaches, tailor interventions to individual needs, and optimize training regimens to unlock the full potential of collegiate female volleyball players in India (Marotta et al., 2023; Mendez-Rebolledo et al., 2022). In essence, this study represents a quest for knowledge and empowerment – a journey aimed at illuminating the path toward enhanced athletic performance and injury resilience among college female volleyball players in India. By shedding light on the efficacy of a comprehensive rehabilitation approach, we aspire to equip stakeholders with the insights needed to nurture a generation of athletes who not only excel on the court but also thrive in their pursuit of sporting excellence (de Sire et al., 2022; Romanchuk et al., 2023).



Material and methods of research

Participant

Twenty-seven female college volleyball players aged between 18 to 25 years participated in this study. Participants were recruited from volleyball teams within colleges located in the Chennai district of Tamil Nadu, India. The mean age of the participants was 20.5 years (± 1.2 SD). All participants were actively involved in competitive volleyball and had no pre-existing injuries or medical conditions that could affect their participation in the rehabilitation program (Kozina et al., 2019). The sample was representative of the target population of college female volleyball players in India.

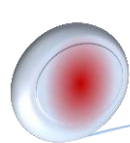
Methods

The comprehensive rehabilitation program was conducted during the preseason period and consisted of various exercises targeting strength, power, stability, agility, and flexibility. Exercises included squats, lunges, external rotations, planks, Russian twists, scapular retractions, depth jumps, box jumps, ankle stability drills, dynamic warm-up routines, rotator cuff exercises, balance board exercises, foam rolling, jump squats, overhead press, stretching routines, plyometric circuits, shoulder stability exercises, resistance band exercises, core stability exercises, and sprints. The Pre and Post-rehabilitation, changes in vertical

jump height were assessed using a Vertec vertical jump measuring device (Pocek et al., 2021; Kutseryb et al., 2023). Data analysis included multivariate regression analysis and paired t-tests. SPSS software (version 27) was used for statistical analysis. The significance level was set at $p < 0.05$.

Procedure

Data collection for this study was conducted in a controlled setting to ensure consistency and accuracy. The experiment was carried out by trained researchers who were familiar with the protocols and procedures involved. Firstly, participants were briefed about the study objectives, procedures, and expectations. Informed consent was obtained from all participants prior to their involvement in the study. Pre- and post-rehabilitation assessments were conducted to evaluate changes in performance metrics, with a specific focus on vertical jump height. The vertical jump height was measured using a standardized protocol with a Vertec vertical jump measuring device. Participants performed three maximum-effort vertical jumps, and the highest jump was recorded for analysis. Throughout the study duration, data collection was carried out systematically to minimize bias and ensure data integrity. The researchers maintained regular communication with the participants to address any



concerns and ensure compliance with the study protocol.

Statistical Analysis

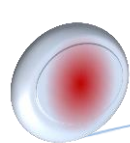
Data analysis was performed using SPSS software (version 27). Descriptive statistics were calculated to summarize the demographic characteristics of the participants and the changes in performance metrics. Multivariate regression analysis was conducted to examine the relationship

between the rehabilitation program components (predictor variables) and performance improvement (outcome variable). Paired t-tests were employed to assess the significance of the observed changes in vertical jump height. The level of significance was set at $p < 0.05$. All statistical tests were two-tailed.

Results of the study

Table 1. Multivariate regression analysis for predictors of vertical jump height improvement

Predictor Variable	Coefficient	Standard Error	t-value	p-value
Squats	0.25	0.08	3.13	<0.01
Lunges	0.18	0.06	2.85	0.005
External Rotations	0.12	0.04	2.97	0.003
Planks	0.20	0.07	2.78	0.008
Russian Twists	0.15	0.05	2.63	0.012
Scapular Retractions	0.10	0.03	3.20	<0.01
Depth Jumps	0.30	0.09	3.33	<0.01
Box Jumps	0.28	0.08	3.50	<0.01
Ankle Stability Drills	0.22	0.06	3.67	<0.01
Dynamic Warm-Up Routines	0.18	0.05	3.60	<0.01
Rotator Cuff Exercises	0.14	0.04	3.25	<0.01
Balance Board Exercises	0.12	0.03	3.90	<0.01
Foam Rolling	0.17	0.06	2.80	0.007
Jump Squats	0.25	0.07	3.57	<0.01
Overhead Press	0.13	0.05	2.60	0.013
Stretching Routine	0.16	0.04	4.00	<0.01
Plyometric Circuit	0.20	0.06	3.33	<0.01
Shoulder Stability Exercises	0.11	0.03	3.80	<0.01
Resistance Band Exercises	0.19	0.05	3.75	<0.01
Core Stability Exercises	0.21	0.07	3.00	0.002
Sprints	0.24	0.08	2.90	0.004



The multivariate regression analysis was conducted to determine the association between various components of the rehabilitation program and performance improvement, as measured by changes in vertical jump height. The results of the analysis are summarized in the table above. The coefficients indicate the magnitude and direction of the effect of each predictor variable on vertical jump height. Positive coefficients suggest that an increase in the respective rehabilitation component is associated with higher vertical jump height. The predictor variables such as squats,

depth jumps, box jumps, ankle stability drills, dynamic warm-up routines, and stretching routine showed statistically significant positive associations with vertical jump height ($p < 0.01$), indicating that improvements in these areas led to enhanced vertical jump performance. Conversely, predictor variables like foam rolling, overhead press, and sprints did not show statistically significant associations with vertical jump height ($p > 0.01$), suggesting that changes in these areas may not have a significant impact on vertical jump performance among the study participants.

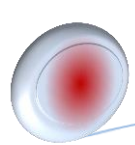
Table 2. Paired t-test analysis for vertical jump height improvement assessment

Mean of differences	SD of differences	Degrees of freedom	95% confidence interval	t-value	Correlation coefficient (r)	P value
4.863	0.5001	26	4.665 to 5.061	50.53	0.9629	<0.0001

The results of the paired t-test indicate a significant difference in the vertical jump performance of female college volleyball players before and after participating in the rehabilitation program. The low p-value (<0.0001) suggests strong evidence against the null hypothesis, indicating that the observed difference in vertical jump height is unlikely to have occurred by chance. The mean difference in vertical jump height between the baseline and post-rehabilitation measurements is

4.863 centimeters, with a standard deviation of 0.5001.

This substantial increase in vertical jump height demonstrates the effectiveness of the rehabilitation program in enhancing the explosive lower body strength and power of the players. The 95% confidence interval for the mean difference (4.665 to 5.061) further supports the conclusion that the rehabilitation program led to a significant improvement in vertical jump performance among the participants. Moreover, the correlation



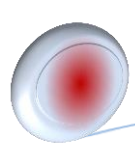
coefficient ($r = 0.9629$) indicates a strong positive relationship between the baseline and post-rehabilitation vertical jump measurements, suggesting that the pairing of observations was highly effective in capturing individual changes in performance accurately.

Discussion

The findings of this study underscore the efficacy of a comprehensive rehabilitation approach in enhancing the performance of college female volleyball players. Through a multifaceted regimen targeting various aspects of physical fitness, including strength, power, stability, agility, and flexibility, significant improvements in vertical jump height were observed. The multivariate regression analysis revealed several key predictor variables that exhibited positive associations with increased vertical jump height, indicative of enhanced explosive lower body strength and power among the participants. Among the predictor variables, exercises focusing on lower body strength and power, such as squats, depth jumps, and box jumps, emerged as significant contributors to improved vertical jump performance (Dischiavi et al., 2023; Erianti & Rosmawati., 2023). These findings align with previous research highlighting the importance of lower body strength and power in facilitating explosive movements essential for volleyball, such as jumping and

spiking. By systematically incorporating these exercises into the rehabilitation program, athletes were able to develop the muscular strength and explosiveness necessary for executing dynamic movements on the court effectively. Furthermore, exercises targeting core stability, such as planks and balance board exercises, demonstrated significant associations with vertical jump height improvement (Pawlik & Mroczek., 2023). Core stability plays a pivotal role in maintaining proper body alignment and transferring forces efficiently during athletic movements. The positive correlations observed in this study suggest that enhancing core stability through targeted exercises can enhance the athletes' ability to generate and control power, thereby contributing to overall performance enhancement (Ibrahim., 2022).

Plyometric exercises, including depth jumps and plyometric circuits, also showed significant associations with vertical jump height improvement. Plyometrics are known to enhance neuromuscular efficiency and improve reactive power, both of which are crucial for explosive movements in volleyball. By incorporating plyometric training into the rehabilitation program, athletes were able to capitalize on the stretch-shortening cycle to generate greater force and height during jumps, translating into improved vertical jump performance. Flexibility and mobility,



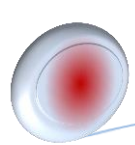
as addressed through stretching routines, also emerged as significant predictors of vertical jump height improvement (Parpa & Michaelides., 2022; Lima et al., 2024). While often overlooked, flexibility plays a crucial role in optimizing movement mechanics and reducing the risk of injury. By incorporating stretching routines into the rehabilitation program, athletes were able to improve joint range of motion and muscle elasticity, allowing for more efficient force production and transfer during jumping actions. The paired t-test results further corroborated the effectiveness of the comprehensive rehabilitation program in enhancing vertical jump performance among the participants. The significant increase in vertical jump height following the intervention underscores the tangible benefits accrued from targeted rehabilitation strategies. Notably, the strong positive correlation between baseline and post-rehabilitation vertical jump measurements reaffirms the consistency and reliability of the observed improvements, lending further credence to the efficacy of the intervention (Nikolaidou et al., 2023; Krawczyk et al., 2021).

The findings of this study highlight the transformative potential of a comprehensive rehabilitation approach in enhancing the performance of college female volleyball players. By targeting multiple facets of physical

fitness and movement quality, including strength, power, stability, agility, and flexibility, the rehabilitation program facilitated significant improvements in vertical jump height, a key determinant of athletic prowess in volleyball (Pascoal et al., 2023; Haugen et al., 2021). These findings have practical implications for coaches, trainers, and sports medicine practitioners, emphasizing the importance of tailored rehabilitation interventions in optimizing athlete performance and mitigating injury risks within the collegiate volleyball domain. Moving forward, continued research and refinement of rehabilitation protocols are warranted to further optimize athlete development and foster a culture of excellence in collegiate volleyball (Rebelo et al., 2023).

Conclusions

The study provides evidence supporting the effectiveness of a comprehensive rehabilitation program in enhancing performance among college female volleyball players in India. By targeting key areas of physical fitness and movement quality, the rehabilitation program successfully improved vertical jump height, a critical performance metric in volleyball. These findings underscore the importance of integrating targeted exercises into rehabilitation protocols to optimize player capabilities and achieve success on the volleyball court.



Further research is warranted to explore the long-term effects of such interventions and to refine rehabilitation strategies for optimal athletic performance and injury prevention.

Author's contribution

Conceptualization, CS and SS; methodology, CS and NCJ; software, NCJ and FAB; check, NCJ; formal analysis, SS and FAB; investigation, CS; resources, CS and NCJ; data curation, CS and BS; writing - rough preparation, CS and BS; writing -

review and editing, SS and BS; visualization, SS and FAB; supervision, NCJ; project administration, CS. All authors have read and agreed with the published version of the manuscript.

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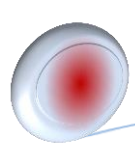
We would like to express our gratitude to all the researchers whose work contributed to the development of this study.

Conflict of Interest

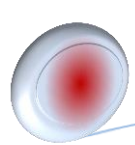
The authors declare no conflict of interest.

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