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Research Article

Influence of Body Composition on Countermovement Jump Performance in Indian Collegiate Athletes

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Abstract:

Background of study: In sports, explosive lower-body power is often the difference between good and great performance, especially in movements like jumping. This study explored how body composition, specifically muscle and fat mass, relates to countermovement jump (CMJ) performance in 60 trained Indian collegiate athletes from various sports backgrounds.

Methods: Using a bioelectrical impedance analyzer, we measured skeletal muscle mass (SMM) and fat mass (FM), while jump metrics like height, peak force, and peak power were captured using a high-frequency force platform.

Result: Our results showed a strong positive link between muscle mass and both peak power ($r = 0.792$) and force ($r = 0.741$), and a moderate connection with jump height ($r = 0.469$). In contrast, fat mass was slightly but negatively related to jump height ($r = -0.248$) and flight time ($r = -0.256$), suggesting that excess fat might hold athletes back in movements requiring quick, explosive effort.

Conclusion: These findings reinforce what many coaches and athletes observe in practice: more muscle, particularly in the lower body, usually means better jump performance, while unnecessary fat can be a limiting factor. The study highlights the importance of looking beyond total body weight and focusing on the quality of mass an athlete carries.

Keywords: Athlete Profiling, Countermovement Jump, Fat Mass, Jump Performance, Skeletal Mass

1. INTRODUCTION

In the realm of sports science and performance analysis, understanding the physiological and biomechanical attributes that contribute to athletic success is of paramount importance (Suchomel et al., 2018). Among these attributes, measuring jump height and a frequently implemented screening tool in sports performance evaluation, the height, peak power, and force-time characteristics are commonly used to track training adaptations, assess fatigue, and inform return-to-play decisions on explosive power, lower-limb neuromuscular function, and the effectiveness of the stretch-shortening cycle (SSC). Parameters like jump in a variety of sporting populations (Bishop et al., 2021; Dobbin et al., 2017; Philpott et al., 2021; An, Su, and Meng, 2024). Because of its simplicity, reliability, and close relationship with athletic performance (e.g. sprinting, jumping, and strength tasks), the CMJ is considered a cornerstone test in strength and conditioning, sports science research, and athletic monitoring protocols (Anicic et al., 2023; Bawari et al., 2023; Jiang, Chen, and Xu, 2024; Sathashivam et al., 2023). Although the biomechanical outcomes of CMJ testing are widely known, research is currently ongoing to determine how morphological characteristics, particularly body composition, affect jump performance. However, further research is needed to adapt and understand CMJ results within the unique context of athletic performance.

Traditionally, bodyweight has been considered a limiting factor in vertical jump performance due to the mechanical requirement of propelling mass against gravity. This perspective has led to the assumption that increased body mass, without a corresponding increase in force production, diminishes jump height and movement efficiency. However, in elite and trained athletic populations, where greater body mass is often accompanied by higher levels of muscle mass and absolute strength,

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this assumption may not hold true. Emerging evidence suggests that lean mass, rather than total bodyweight, may be a more functionally relevant predictor of CMJ performance (Legg et al., 2023; Milošević et al., 2024). Lean body mass contributes directly to force and power production during explosive actions like the CMJ, whereas fat mass represents a passive load that may compromise movement economy. Scientifically, it is well-established that changes in weight can introduce variations in power development (Ackland et al., 2009; Ben Mansour et al., 2021). As a result, relying solely on total bodyweight may obscure the specific contributions of different body composition components to athletic performance. To optimize athlete monitoring, training strategies, and individualized performance profiling, a clearer understanding of how lean mass, fat mass, and their relative proportions influence CMJ mechanics is essential.

The aim of this study is to investigate the relationship between body composition and CMJ performance factors in a mixed-sport collegiate athlete group. This study seeks to determine the extent to which lean mass serves as a predictor of vertical leap ability by disentangling the effects of bodyweight into its constituent constituents. Such findings may have practical applications in talent identification, strength and conditioning programs, and tailored performance benchmarking in sports.

2. MATERIAL AND METHOD

2.1 Participants:

Fifty trained Indian college level athletes (n = 60), comprising both male and female participants, were recruited from various sports. Inclusion criteria required participants to be injury-free for at least 1 year prior to testing and actively involved in structured training programs. Written informed consent was obtained from all participants.

2.2 Study Design:

This study aimed to investigate the relationship between jump height and body composition, peak force, peak power. Testing was conducted in a single session in a controlled laboratory environment to ensure consistency of measurement conditions.

2.3 Measure and Procedure:

Body Composition Assessment:

Body composition variables were assessed using the InBody 970 (Seoul, South Korea) bioelectrical impedance analysis (BIA) device. Measurements were taken in the morning after an overnight fast and following standardized hydration and activity restrictions (e.g., no vigorous exercise within 12 hours and no caffeine or alcohol 24 hours prior). The following variables were taken: Skeletal Muscle Mass (kg), Fat Mass (kg), Total Body Weight (kg).

Countermovement Jump Assessment:

CMJ performance was assessed using a force platform with strain gauge technology (Sampling Rate: 1000 Hz). Participants performed three maximal CMJ trials with hands on hips to eliminate arm swing influence. Each jump began from an upright standing position, followed by a rapid downward movement and immediate upward propulsion. A 60-second rest was provided between trials to minimize fatigue effects. The following CMJ variables were recorded: Jump Height (cm), Peak Force, Peak Power. The best trial (i.e., highest jump height) was selected for statistical analysis.

2.4 Statistical Analysis:

All statistical analyses were conducted using MS Excel. Statistical significance was set at $p < 0.05$. Descriptive statistics (mean ± SD) were calculated for all variables. Pearson's correlation coefficients were used to assess relationships between jump height and lean mass, fat mass and total body mass.

3. RESULT AND DISCUSSION

3.1 Result

Table 1. The descriptive details of anthropometric characteristics of the study population

Anthropometric Detail	Mean ± S.D.
Height (cm)	166.70± 9.96
Body Mass (kg)	60.30± 14.55
Age (years)	19.98± 4.83
SMM (kg)	26.62 ± 6.50
FM (kg)	12.67 ± 6.67

Relationship Between Skeletal Muscle Mass and CMJ Performance

Skeletal muscle mass (SMM) demonstrated significant positive correlations with all three primary CMJ performance indicators. The strongest relationship was observed between peak power and SMM (r = 0.792), indicating a robust association between greater muscle mass and power output during jumping. Similarly, force production showed a strong positive correlation with SMM (r = 0.741), suggesting enhanced force-generating capacity in individuals with higher muscle mass. A moderate positive correlation was also found between jump height and SMM (r =

0.469), implying that although SMM contributes to vertical performance, its influence on jump height is less pronounced than on force and power.

Relationship Between Fat Mass and CMJ Performance

In contrast to SMM, fat mass (FM) exhibited weak negative correlations with CMJ performance parameters. Jump height was negatively correlated with FM (r = -0.248), indicating that higher fat mass may reduce vertical jump performance. Similarly, flight time was negatively associated with FM (r = -0.256), suggesting that individuals with greater fat mass tend to spend less time in the air during a jump. Although these correlations were not as strong as those observed with SMM, they nonetheless highlight the potential adverse impact of fat mass on explosive lower-limb actions.

Table 2. Descriptive details of the Jump Parameters

Jump Parameters	Mean ± S.D.
Jump Height (cm)	40.77 ± 10.68
Peak Force (N)	1348.47 ± 361.60
Flight Time (sec)	0.48 ± 0.08
Peak Power (watts)	2624.96 ± 926.99

3.2 Discussion

This study explored how body composition, particularly skeletal muscle mass (SMM) and fat mass (FM), relates to countermovement jump (CMJ) performance among Indian collegiate athletes. By focusing on a population that is underrepresented in the literature, this research not only supports findings from global studies but also reveals context-specific trends that may be unique to Indian athletes. The application of standardized protocols, including bioelectrical impedance analysis (BIA) for measuring body composition and a high-frequency force platform for assessing CMJ, ensured a robust evaluation of these relationships.

Skeletal Muscle Mass and Jump Performance

One of the key outcomes was the strong positive link between skeletal muscle mass and peak power output during the CMJ (r = 0.792). This aligns with existing evidence suggesting that greater lean mass enhances neuromuscular power, especially in explosive, lower-body movements. Since skeletal muscle serves as the primary driver for force generation, it makes intuitive sense that individuals with more muscle mass tend to perform better in jumping tasks. The increased muscle cross-sectional area contributes to improved motor unit activation, thereby optimizing force development over time.

Similarly, the correlation between SMM and peak force (r = 0.741) further underlines the role of muscular development in enhancing power output. These findings reinforce the idea that strength and hypertrophy can directly contribute to better performance in explosive athletic tasks. While the relationship between SMM and jump height was moderately strong (r = 0.469), it remains noteworthy. Vertical jump height is influenced by a combination of factors, including the rate of force application, coordination, stretch-shortening cycle efficiency, and technique. The slightly lower correlation may reflect the more complex nature of jump height, which goes beyond raw force output.

Comparable patterns have been noted in earlier studies. For instance, (Raymond-Pope et al., 2020) found a very high correlation (r = 0.94) between lower-body lean mass and squat jump height among elite collegiate athletes. While the present correlations are somewhat lower, this variation could stem from methodological differences, such as BIA versus DXA for body composition, or the use of CMJ instead of squat jump, as well as population-specific characteristics. Nevertheless, the evidence presented here adds further support to the role of muscle mass in enhancing jump-related power.

Fat Mass and Jump Performance

In contrast, fat mass exhibited weak but negative correlations with jump height (r = -0.248) and flight time (r = -0.256). Although these relationships are not particularly strong, they suggest that higher fat mass may hinder performance by contributing non-functional body weight that must be lifted during a jump. Unlike muscle, fat does not assist in force production, meaning athletes with higher fat mass may experience a reduction in movement efficiency and jump effectiveness.

These trends are consistent with prior research, such as the study by (Legg et al., 2021), which reported a much stronger inverse relationship (r = -0.82) between fat percentage and CMJ performance. The discrepancy in correlation strength could be due to differences in assessment tools, DXA and accelerometers in their study versus BIA and a force platform in the current one. BIA, while practical, may not capture fat distribution with the same precision as DXA.

Furthermore, different CMJ measurement methods may yield varying levels of sensitivity.

Interestingly, some research shows even weaker negative correlations. For example, (Acar & Eler, 2019) found a weaker association (r ≈ -0.40) between body fat and jump height in elite volleyball players. This suggests that sport-specific demands, training status, and individual variability all play a role in how fat mass affects jump performance. Despite these nuances, the general trend remains clear, excess fat mass tends to impair explosive movement performance.

Methodological and Contextual Considerations

A major strength of this study is the use of a high-frequency force platform, which is widely regarded as a gold standard for capturing kinetic variables during jumping. By analyzing multiple performance indicators, peak power, force, and flight time, the study offers a more comprehensive view of jump mechanics than relying on jump height alone. Moreover, the inclusion of trained Indian collegiate athletes adds a valuable perspective to a field that often emphasizes Western or elite athletic populations.

It is important to acknowledge, however, that jump performance is influenced by many factors beyond muscle and fat mass. Variables such as tendon stiffness, muscle fiber composition, coordination, and neuromuscular efficiency all play roles. As a result, individuals with less muscle mass may still excel in jumping due to superior technique or reactive strength.

The moderate strength of some observed relationships also points to the importance of considering relative values, such as SMM in relation to body weight, rather than absolute measures. Future studies could benefit from examining ratios like muscle-to-fat or power-to-weight, which may provide deeper insights into athletic capability.

3.2.1 Implication

The results of this study have clear implications for athlete development and training. Strength and conditioning professionals should prioritize increasing lean muscle mass while managing fat levels to optimize power-related outcomes, especially in sports where lower-body explosiveness is critical. These findings can also inform talent identification processes and help create performance benchmarks tailored to individual athletes.

Moreover, this research highlights the value of routine body composition monitoring in sports settings. Rather than focusing solely on total body weight, a more detailed analysis of muscle and fat proportions offers better context for evaluating athletic performance potential.

3.2.2 Research Contribution

This study contributes to the existing body of knowledge by providing empirical evidence on the relationship between body composition and countermovement jump performance in Indian collegiate athletes, a population that is relatively underrepresented in the literature. The findings highlight that skeletal muscle mass is a stronger predictor of power and force production compared to total body weight, while fat mass negatively influences jump efficiency. Practically, the study offers valuable insights for coaches and practitioners to focus on optimizing lean mass and managing fat levels in athlete profiling, talent identification, and strength and conditioning programs.

3.2.3 Limitation Suggestion

While the study offers useful insights, it is not without limitations. BIA, despite being a practical tool, is sensitive to factors like hydration status, which can influence its accuracy. The sample size (n = 60) also limits how broadly the findings can be applied. Expanding the participant pool and examining specific subgroups, such as endurance versus power athletes, could provide more nuanced conclusions.

3.2.4 Suggestion

Future research should also consider analyzing segmental body composition, particularly in the lower limbs, to better understand how regional muscle and fat distribution impact jump performance. Additionally, incorporating different types of jump tests (e.g., squat jumps, drop jumps) and neuromuscular assessments would further enrich our understanding. Longitudinal studies tracking changes in body composition and performance over time would be particularly valuable for evaluating training effectiveness and adaptation.

4. CONCLUSION

The results of this study indicated that muscle mass and fat mass can be a good predictor of countermovement jump performance. Athletes with higher muscle mass have higher jump height and peak force production during a jump performance. Hence, increasing skeletal muscle mass can help improve jump performance in sports where lower body explosive power is an important performance indicator. However, more studies are need to effectively evaluate the effect of gender, training load and individual variations among a large population of athletes.

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6. AUTHOR CONTRIBUTION STATEMENT

All the authors contributed equally towards formulation of this manuscript. PK and RT conceptualized and designed the study; PK and TS collected and analyzed the data; PK, TS and RT wrote and reviewed the manuscript.

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