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Original Scientific Article

Determining the Correlation of Fat-Free Mass, Power, and Maximum Hamstring Force in Female Basketball Athletes

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Abstract

Background. In competitive sports, especially basketball, physical attributes such as agility, speed, strength, and power are crucial for performance.

Objectives. This study aimed to examine the correlation between fat-free mass (FFM), countermovement jump (CMJ) power, and maximum hamstring force in female basketball athletes, providing insights that could enhance performance and reduce injury risk.

Materials and methods. This observational cross-sectional study investigates the relationship between fat-free mass (FFM), power, and maximum hamstring force in 45 female basketball athletes. The Anderson-Darling test for assessing normality and Spearman's correlation for non-normally distributed data were used to conduct the study.

Results. Significant correlations were found between FFM and maximum hamstring force in the both right ($r = 0.585$, $p < 0.001$) and left legs ($r = 0.522$, $p < 0.001$), as well as between (CMJ) power and maximum hamstring force for both legs (right: $r = 0.467$, $p = 0.001$; left: $r = 0.434$, $p = 0.003$). Additionally, power was significantly correlated with jump height ($r = 0.604$, $p < 0.001$).

Conclusions. These findings suggest that FFM and power are critical determinants of hamstring strength and explosive performance in female basketball athletes.

Keywords: fat-free mass, hamstring force, power, correlation, female basketball athletes.

Introduction

The level of female participation in basketball has been on the rise, reflecting growing interest and enthusiasm for the sport among women. Despite this positive trend, there remains a significant gap between the ideal physical attributes desired in basketball and the current state of female participation. Women in basketball often face several challenges, including limited access to high-quality training facilities, societal stereotypes, and less media coverage compared to their male counterparts (Bell et al., 2014). These obstacles can hinder the development and recognition of female athletes. Nevertheless, the benefits of participating in basketball for women are profound. The sport enhances physical fitness, cardiovascular health, and muscle strength. It also fosters teamwork, leadership skills, and self-confidence, contributing significantly to personal and professional growth. Additionally, the increasing visibility of women's basketball at the collegiate and professional levels has created more opportunities for scholarships and careers, encouraging more young women to pursue the sport seriously (Petridis et al., 2019).

Understanding the factors that contribute to athletic performance in female basketball players is crucial for optimizing training and reducing injury risks. Data indicates that specific physical attributes, such as fat-free mass (FFM), coun-

termovement jump (CMJ) power, and maximum hamstring force, play pivotal roles in performance outcomes. For example, an analysis of WNBA players' profiles revealed that athletes with higher CMJ power had significantly better performance metrics (Heishman et al., 2020). Diana Taurasi, one of the top WNBA players, exhibits exceptional CMJ power, which correlates with her ability to achieve high jump heights and explosive movements on the court. This correlation between CMJ power and performance highlights the importance of explosive strength in basketball. Such insights can inform tailored training regimens focused on enhancing FFM, CMJ power, and hamstring strength, ultimately leading to improved athletic performance and reduced injury risks (Lee et al., 2024).

To enhance the performance and reduce the injury risk of female basketball athletes, it is essential to conduct comprehensive assessments of FFM, CMJ power, and maximum hamstring force. Implementing regular testing and monitoring of these variables can help in developing personalized training programs that address individual needs and weaknesses (Chen et al., 2013). Additionally, improving access to high-quality training facilities and coaching for female athletes can bridge the gap between current participation levels and the desired physical attributes for basketball. By leveraging scientific insights and tailored training strategies, the development and success of female basketball players can be significantly enhanced (Cabarkapa et al., 2023).

In competitive sports, particularly basketball, the physical attributes of athletes play a crucial role in performance outcomes. Basketball requires a unique blend of skills, including agility, speed, strength, and power, each of which contributes to an athlete's ability to perform essential movements such as jumping, sprinting, and rapidly changing direction (Akkoc et al., 2018). Understanding the intricate relationship between body composition, muscle strength, and explosive power is essential for optimizing training and injury prevention strategies tailored to the specific demands of basketball (Cirillo et al., 2023). This study aims to explore the correlation between fat-free mass (FFM), countermovement jump (CMJ) power, and maximum hamstring force in female basketball athletes, providing insights that could enhance performance and reduce injury risk.

Fat-free mass (FFM), which includes muscle mass, bone mass, and water content, is a critical determinant of athletic performance. Higher FFM is associated with greater muscle strength and power, which are vital for the explosive movements required in basketball, such as jumping, sprinting, and quick directional changes (Aikawa et al., 2020). Research has shown that athletes with higher muscle mass exhibit superior performance in strength and power-related tasks. FFM not only contributes to physical performance but also plays a significant role in metabolic health. Higher levels of FFM can increase the resting metabolic rate, which aids in maintaining optimal body composition and energy levels necessary for high-intensity sports (Torgutalp et al., 2022). The enhancement of FFM through resistance training and adequate protein intake is a well-documented approach in sports science aimed at improving athletic capabilities and reducing fat mass. This dual benefit makes FFM a key focus in the training regimens of basketball athletes (Zouita et al., 2023).

The countermovement jump (CMJ) is a widely used measure of lower body explosive power. It reflects an athlete's ability to generate force rapidly, which is crucial for jumping and sprinting actions in basketball. CMJ performance has been positively correlated with athletic success in various sports, highlighting its importance as an indicator of explosive power (Andreyo et al., 2024). Studies have shown that higher CMJ power is associated with improved performance in sprinting and jumping tasks. CMJ power is not only an indicator of explosive strength but also provides insights into the neuromuscular function of an athlete (Mocanu, 2023). The ability to produce a high power output during a CMJ requires optimal coordination between the nervous and muscular systems. This coordination is essential for executing rapid and forceful movements, which are common in basketball. Therefore, CMJ power serves as a comprehensive measure of an athlete's explosive capabilities and overall conditioning (AlSamhori et al., 2023).

Hamstring strength is essential for both performance and injury prevention in basketball. Strong hamstrings contribute to better sprinting speed, jumping ability, and overall lower body stability (Özkan et al., 2024). Moreover, adequate hamstring strength can reduce the risk of injuries, particularly hamstring strains, which are common in sports that involve high-speed running and sudden changes in direction. The hamstrings play a crucial role in deceleration, a frequent action in basketball when athletes must quickly stop or change direction (Jiang et al., 2023). Given the high incidence of hamstring injuries in basketball, understanding the factors that influence hamstring strength is crucial for developing effective conditioning programs. Hamstring injuries can have a significant impact on an athlete's career, often leading to prolonged periods of inactivity and rehabilitation. Therefore, identifying the relationship between hamstring strength and other physical attributes such as FFM and CMJ power can help in designing targeted interventions to enhance performance and reduce injury risk (Palma-Muñoz et al., 2021).

Female athletes often exhibit different muscle distribution and strength characteristics compared to their male counterparts. These differences can influence how body composition and power translate into athletic performance. Exploring these factors in female athletes can provide valuable insights for coaches and trainers who aim to optimize training programs specifically for women (Torgutalp et al., 2022). This study aims to fill this gap by exploring the correlation between FFM, CMJ power, and maximum hamstring force in female basketball athletes. Identifying these relationships is essential for developing targeted training interventions that enhance performance and reduce the risk of injury. By understanding how FFM and power contribute to hamstring strength, coaches and trainers can design more effective conditioning programs that address the specific needs of female basketball players (Nikolaidis et al., 2015).

This study aims to fill this gap by exploring the correlation between FFM, CMJ power, and maximum hamstring force in female basketball athletes. Identifying these relationships is essential for developing targeted training interventions that enhance performance and reduce the risk of injury. By understanding how FFM and power contribute to hamstring strength, coaches and trainers can design more effective conditioning programs that address the specific needs of female basketball players.

Materials and Methods

Study Participants

This cross-sectional observational study involved 45 female basketball athletes aged 16.5 ± 1.1 years. The mean body weight of the participants was 57.7 ± 9.4 kg, their mean height

was 163.8 ± 7.0 cm, and their mean body mass index (BMI) was 21.4 ± 2.6. These athletes were selected from four teams that had reached the semifinal phase of a competitive tournament.

Study Organization

Body Composition Measurement: Body composition, including fat-free mass (FFM), was measured using bioelectrical impedance analysis (BIA). The purpose of using BIA was to accurately determine the athletes' FFM, which is essential for understanding their physical makeup.

Physical Performance Assessment: Countermovement Jump (CMJ) Power, CMJ power was measured using a force plate to capture jump height and calculate power output. This assessment aimed to evaluate the explosive power of the athletes. Maximum Hamstring Force, this was evaluated using an isokinetic dynamometer, which provided detailed measurements of hamstring muscle strength. This method was used to assess the maximum force generation capacity of the hamstring muscles.

Research Procedures and Algorithm: Selection of participants from the semifinal teams, measurement of body composition using BIA. Assessment of CMJ power using a force plate. Evaluation of maximum hamstring force using an isokinetic dynamometer.

Statistical Analysis

Normality Test: The Anderson-Darling test was used to test the normality of the data. This test was chosen to determine whether the data followed a normal distribution, which is a prerequisite for many statistical analyses.

Correlation Analysis: Since the data were not normally distributed, Spearman's correlation coefficient was employed to analyze the relationships between FFM, CMJ power, and maximum hamstring force. Spearman's correlation is suitable for non-normally distributed data as it assesses the strength and direction of the association between two ranked variables.

Software and Data Presentation: All data analyses were conducted using MINITAB version 21 software. Scatter plots were used to visually present the data and illustrate the correlations between the measured variables.

Results

The data analysis identified significant positive correlations between fat-free mass (FFM) and maximum hamstring force for both the right leg ($r = 0.585$, $p < 0.001$) and the left leg ($r = 0.522$, $p < 0.001$). This indicates that individuals with higher FFM tend to exert greater maximum force in their hamstrings. Furthermore, countermovement jump (CMJ) power showed significant positive correlations with maximum hamstring force for the right leg ($r = 0.467$, $p = 0.001$) and the left leg ($r = 0.434$, $p = 0.003$), suggesting that greater leg power is associated with stronger hamstrings. Lastly, a strong positive correlation was observed between CMJ power and jump height ($r = 0.604$, $p < 0.001$), indicating that higher power output during a jump is associated with increased jump height.

The data above shows that there is a correlation between fat-free mass (FFM) and maximum hamstring muscle strength with a correlation value of 0.52 and a p-value < 0.001.

The data above shows that there is a correlation between countermovement jump (CMJ) and maximum left hamstring muscle strength with a correlation value of 0.43 and a p-value < 0.003.

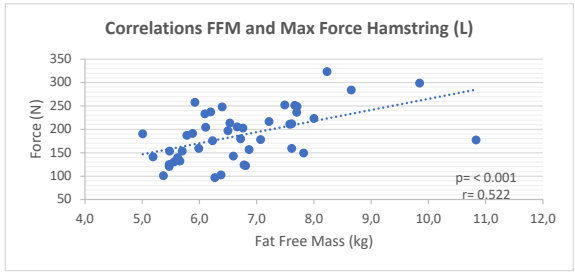

Fig. 1. Correlations FFM and Max Force Hamstring (L)

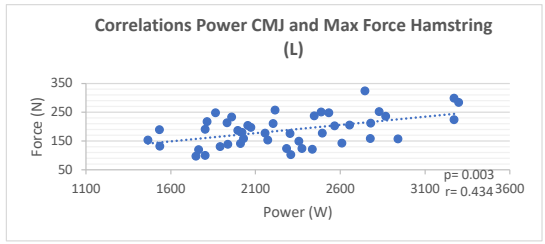

Fig. 2. Correlations Power CMJ and Max Force Hamstring (L)

The data above shows that there is a correlation between countermovement jump (CMJ) and maximum right hamstring muscle strength with a correlation value of 0.46 and a p-value < 0.001.

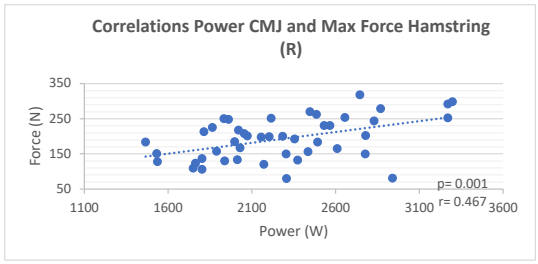

Fig. 3. Correlations Power CMJ and Max Force Hamstring (R)

The data above shows that there is a correlation between countermovement jump (CMJ) power and jump height ability with a correlation value of 0.6 and a p-value < 0.001.

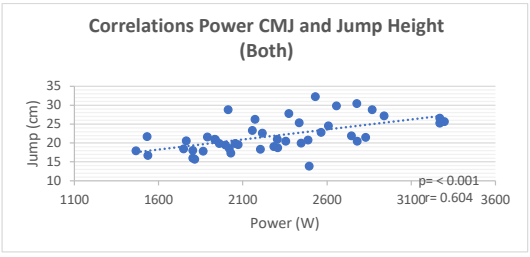

Fig. 4. Correlations Power CMJ and Jump Height (Both)

Discussion

The findings of this study underscore the importance of fat-free mass (FFM) and power in enhancing hamstring strength and explosive performance among female basketball athletes. The significant correlation between

FFM and maximum hamstring force highlights the role of muscle mass in generating force. This is consistent with previous research demonstrating that greater muscle mass contributes to higher force production capabilities (Jiang et al., 2023). FFM, which includes muscle mass, bone mass, and other non-fat tissues, is critical in force generation because muscles are the primary drivers of movement and force production (Campos et al., 2023).

The significant correlations between countermovement jump (CMJ) power and maximum hamstring force for both legs further emphasize the link between explosive power and muscle strength. CMJ power, a measure of an individual's ability to generate force quickly, is crucial for activities requiring rapid movements and high force output (Bell et al., 2014). This measure is particularly important in sports like basketball, where athletes frequently need to jump, sprint, and change directions quickly. The positive correlations suggest that individuals with greater power output also possess stronger hamstrings, which can be beneficial for athletic performance, particularly in sports requiring explosive lower body movements (Brumitt et al., 2013). This supports the notion that training to improve power can have direct benefits on strength, contributing to better performance in dynamic sports scenarios (Annino et al., 2017).

Moreover, the strong correlation between CMJ power and jump height illustrates the impact of power on vertical jump performance. Higher power output enables individuals to achieve greater jump heights, a key performance indicator in various sports (Chen et al., 2013). This relationship highlights the importance of power training for athletes aiming to improve their jump performance. Jump height is not only crucial for basketball but also for other sports like volleyball, soccer, and track and field, where explosive lower body movements are essential for optimal performance (Cuthbert et al., 2021). Effective power training can include plyometric exercises that focus on explosive movements, thereby improving the neuromuscular adaptations necessary for enhanced jump performance (Heishman et al., 2020).

These results have practical implications for training programs, emphasizing the need for strength and conditioning protocols that enhance FFM and power to improve athletic performance and reduce injury risk. Training programs that focus on increasing muscle mass and enhancing power output can lead to stronger hamstrings and improved jump performance, which are critical for basketball athletes (Palma-Muñoz et al., 2021). Strength and conditioning protocols should incorporate exercises targeting muscle hypertrophy and explosive power to maximize performance gains. For instance, plyometric exercises such as box jumps, squat jumps, and depth jumps can significantly enhance explosive power. Resistance training, particularly focusing on the lower body with exercises like squats, deadlifts, and leg presses, can increase muscle mass and strength, thereby improving overall athletic performance (Nikolaidis et al., 2015). Additionally, incorporating eccentric training, which emphasizes the lengthening phase of muscle contraction, can be beneficial for increasing muscle strength and reducing injury risk.

Future research should investigate longitudinal changes in these parameters and their impact on performance and injury prevention in a broader athletic population. Long-term studies could provide deeper insights into how sustained improvements in FFM and power influence overall athletic performance and reduce the risk of hamstring injuries, which are common in sports (McCaskie et al., 2023) requiring explosive movements. Understanding the long-term effects of training interventions can help in designing more effective strength and conditioning programs tailored to the specific needs of athletes, thereby enhancing performance and minimizing injury risks over the course of an athlete's career (AlSamhori et al., 2023). Such research could also explore the optimal training volumes and intensities needed to maximize gains in muscle mass and power while minimizing the risk of overtraining and injury (Gerodimos et al., 2023).

Conclusions

This study highlights the critical role of fat-free mass (FFM) and power in enhancing hamstring strength and explosive performance among female basketball athletes. The significant positive correlations between FFM and maximum hamstring force indicate that greater muscle mass contributes to higher force production capabilities in the hamstrings. Similarly, the strong correlations between countermovement jump (CMJ) power and both maximum hamstring force and jump height underscore the importance of explosive power in muscle performance and overall athletic ability. These findings have practical implications for designing strength and conditioning programs tailored to female basketball athletes. Emphasizing protocols that enhance FFM and power can lead to stronger hamstrings, improved jump performance, and reduced injury risk. Specifically, incorporating exercises that target muscle hypertrophy and explosive power will be beneficial in maximizing athletic performance.

Future research should focus on longitudinal studies to explore how sustained improvements in FFM and power influence performance and injury prevention across a broader athletic population. Understanding these relationships over time will provide deeper insights into optimizing training interventions and enhancing the long-term health and performance of athletes. In summary, this research provides valuable insights into the biomechanical factors that influence performance in female basketball athletes. By targeting FFM and power in training programs, coaches and trainers can significantly improve their athletes' strength, explosive capabilities, and overall athletic performance, ultimately leading to better outcomes on the court and a reduced risk of injuries.

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Conflict of Interest

There are no conflict of interest.

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Визначення кореляції показників безжирової маси тіла, потужності та максимальної сили підколінного сухожилля у спортсменок-баскетболісток

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 6 с., 4 рис., 24 джерела.

Історія питання. У змагальних видах спорту, зокрема в баскетболі, фізичні якості, як-от спритність, швидкість, сила та потужність, є визначальними чинниками для досягнення результативності.

Мета дослідження. Мета дослідження полягала у вивченні кореляції між показниками безжирової маси (БЖМ) тіла, потужності вертикального стрибка з контррухом (ВСК) та максимальної сили підколінного сухожилля у спортсменок-баскетболісток, що сприятиме підвищенню рівня результативності та зниженню ризику травмування.

Матеріали та методи. У цьому обсерваційному поперечному дослідженні вивчався взаємозв'язок між показниками безжирової маси (БЖМ) тіла, потужності та максимальної сили підколінного сухожилля у 45 спортсменок-баскетболісток. З метою проведення дослідження використовували критерій Андерсона-Дарлінга для оцінки нормальності розподілу величин та рангову кореляцію Спірмена для ненормально розподілених даних.

Результати. Встановлено значні кореляційні зв'язки між показниками безжирової маси тіла і максимальної сили підколінного сухожилля правої ($r = 0,585$, $p < 0,001$) і лівої ноги ($r = 0,522$, $p < 0,001$), а також між потужністю вертикального стрибка з контррухом і максимальною силою підколінного сухожилля для обох ніг (права: $r = 0,467$, $p = 0,001$; ліва: $r = 0,434$, $p = 0,003$). Крім того, показник потужності суттєво корелював з висотою стрибка ($r = 0,604$, $p < 0,001$).

Висновки. Отримані дані свідчать про те, що показники безжирової маси тіла і потужності є вирішальними чинниками, що визначають силу підколінного сухожилля та вибухову продуктивність у спортсменок-баскетболісток.

Ключові слова: безжирова маса тіла, сила підколінного сухожилля, потужність, кореляція, спортсменки-баскетболістки.

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