Sportis
Revista Técnico-Científica del Deporte Escolar, Educación Física y Psicomotricidad
Scientific Technical Journal of School Sport, Physical Education and Psychomotricity

Published by: Campus Educa Sportis. Collaborator: University of A Coruña A Coruña. Spain

E-mail: v.arufe@udc.es Web: www.sportisjournal.com

ISSN-e 2386-8333

Original article. The difference between male and female countermovement jump performance in junior basketball players Vol. 11, n. º 3; p. 1-16, July 2025. https://doi.org/10.17979/sportis.2025.11.3.11860

The difference between male and female countermovement jump performance in junior basketball players

Diferencias entre el rendimiento de salto con contramovimiento masculino y femenino en jugadores de baloncesto juveniles

Nur Luthfiatus Solikah[1], Awang Firmansyah[2]*, Achmad Widodo[2], Heri Wahyudi[2], Diva Ristie Valentina[3], Andika Bayu Putro[4], Muhammad Reza Aziz Prasetya[5] , Mohammed Elgammal[6]

[1]Physiotherapy Program, Faculty of Medicine, Universitas Negeri Surabaya, Indonesia

[2]Sport Science Program, Faculty of Sport Science and Health, Universitas Negeri Surabaya, Indonesia

[3]Physical Education Program, Faculty of Sport Science and Health, Universitas Negeri Surabaya, Indonesia

[4]Sport Science Program, School of Pharmacy, Institut Teknologi Bandung, Indonesia

[5]Allied Health Program, Departement of Physical Therapy, National Cheng Kung University, Taiwan

[6]Faculty of Physical Education, Zagazig University, Egypt

*Correspondence Author: Awang Firmansyah, awangfirmansyah@unesa.ac.id

Editorial schedule: *Article received 15/03/2025 Accepted: 30/04/2025 Published: 01/07/2025*

https://doi.org/10.17979/sportis.2025.11.3.11860

To cite this article use the following reference:
Solikah, N.L.; Firmansyah, A.; Widodo, A.; Wahyudi, H.; Valentina, D.R.; Putro, A.B.; Prasetya, M.R.A.; Elgammal, M. (2025). The Difference between Male and Female Countermovement Jump Performance in Junior Basketball PlayersSportis Sci J, 11 (3), 1-16 https://doi.org/10.17979/sportis.2025.11.3.11860

Author contribution: Not applicable.

Funding: The study receives funding by Universitas Negeri Surabaya.

Conflict of interest: The authors declare that they have no conflict of interest.

Ethical aspects: The study declares the ethical aspects

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Abstract

The countermovement jump is an important test for basketball athletes, and this study aims to determine the differences in countermovement jump performance between male and female athletes. A total of 24 elite youth athletes (12 males: 17.8 ± 0.8 years, height 187.4 ± 8.7 cm, weight 79.9 ± 15.1 kg, BMI 22.6 ± 3.1 kg/m², PBF 9.6 ± 3.3%; and 12 females: 16.8 ± 0.8 years, height 172.8 ± 4.6 cm, weight 63.4 ± 7.9 kg, BMI 21.2 ± 2.2 kg/m², PBF 20.2 ± 5.1%) were selected through the elite athlete process selection and participated in a countermovement jump test using a force plate. Mean values for men at flight time 577.8 ± 31.7 m/s, jump height 41.1 ± 4.5 cm, peak power 4644.0 ± 839.0 W while for women 455.2 ± 26.0 m/s, jump height 25.5 ± 2.9 cm, peak power 2749.0 ± 298 W. All these tests have a significant correlation. All of these tests have a significant correlation in the results of the difference in the performance of the countermovement jump test (sig. <0.05) and the results of the correlation between Percent body fat (PBF) and Countermovement jump (CMJ) show a significance of <0.05, while BMI and CMJ also show a correlation of <0.05, except for the flight time variable. Measuring jump height and flight time is essential for monitoring fatigue and enhancing performance in young basketball players. These benchmarks help athletes and coaches strive for elite-level performance based on gender.

Keywords: jumping, basketball, adolescent, athletic performance, lower extremity

Resumen

El salto con contramovimiento es una prueba importante para los atletas de baloncesto y este estudio tiene como objetivo determinar las diferencias en el rendimiento del salto con contramovimiento entre atletas masculinos y femeninos. Un total de 24 atletas jóvenes de élite (12 hombres: 17,8 ± 0,8 años, altura 187,4 ± 8,7 cm, peso 79,9 ± 15,1 kg, IMC 22,6 ± 3,1 kg/m², PBF 9,6 ± 3,3%; y 12 mujeres: 16,8 ± 0,8 años, altura 172,8 ± 4,6 cm, peso 63,4 ± 7,9 kg, IMC 21,2 ± 2,2 kg/m², PBF 20,2 ± 5,1%) fueron seleccionados a través del proceso de selección nacional y participaron en una prueba de salto con contramovimiento utilizando una plataforma de fuerza. Valores medios para hombres en tiempo de vuelo 577,8 ± 31,7 m/s, altura de salto 41,1 ± 4,5 cm, potencia pico 4644,0 ± 839,0 W mientras que para mujeres 455,2 ± 26,0 m/s, altura de salto 25,5 ± 2,9 cm, potencia pico 2749,0 ± 298 W. Todas estas pruebas tienen una correlación significativa. Todas estas pruebas tienen una correlación significativa en los resultados de la diferencia en el rendimiento de la prueba de salto con contramovimiento (sig. <0,05) y los resultados de la correlación entre Porcentaje de grasa corporal (PBF) y Salto con contramovimiento (CMJ) muestran una significancia de <0,05, mientras que el IMC y el CMJ también muestran una correlación de <0,05, excepto para la variable tiempo de vuelo. Medir la altura de salto y el tiempo de vuelo es esencial para controlar la fatiga y mejorar el rendimiento en jugadores de baloncesto jóvenes. Estos puntos de referencia ayudan a los atletas y entrenadores a esforzarse por alcanzar un rendimiento de nivel élite en función del género.

Palabras clave: salto, baloncesto, adolescente, rendimiento atlético, extremidades inferiores.

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Introduction

Basketball is a globally popular team sport that requires high-intensity, repetitive movements such as acceleration and deceleration (Stojanović et al., 2018). Professional leagues like the NBA have demanding schedules, with 82 matches played over six months (Edwards et al., 2018). Successful performance relies on well-coordinated teamwork, with players fulfilling distinct roles (Sampaio et al., 2006). To understand the physical demands of the game, it is essential to examine the energy systems activated during gameplay (Scanlan et al., 2011). Basketball, as a sport characterized by its dynamic and intermittent nature, heavily relies on both the anaerobic energy system—which provides short bursts of energy for high-intensity actions—and the aerobic system, which supports sustained physical effort (Ben Abdelkrim et al., 2007). This interplay ensures athletes can maintain peak performance throughout a game.

One key physical ability that plays a pivotal role in basketball performance is jumping. Basketball primarily relies on anaerobic movements, including jumping for rebounds, blocking, shooting, sprinting, and quick directional changes (Latorre Román et al., 2018). Jumping ability significantly influences a team's performance and overall success (Correia et al., 2020). The act of jumping is a complex movement requiring coordination of multiple muscle groups across the torso, arms, and legs (Pomohaci & Sopa, 2021). Additionally, jumping capability is positively correlated with future athletic achievement and competitive success (Teramoto et al., 2017). In this context, explosive lower-limb muscle power is fundamental for executing basketball-specific actions such as rebounding, shooting, and blocking (Correia et al., 2020). It also underpins key skills like sprinting, rapid directional changes, and overall agility, all of which require maximal strength and speed (Candra et al., 2017). Therefore, athletes must be able to react quickly and explosively in short time frames during competitions (Warneke et al., 2022), such as sprinting, dribbling, shuffling, jumping, and changing direction (Ben Abdelkrim et al., 2010), with jumping being a core demand of the sport (Alemdaroğlu, 2012). Maintaining high physical fitness is essential for success (Ivanović et al., 2022), and vertical jump tests are commonly used to assess muscular power and help identify athletes with higher performance potential (Cui et al., 2019).

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Beyond performance enhancement, muscle strength deficits—especially imbalances—are critical indicators of injury risk and athlete readiness (Grindem et al., 2016). Coaches and sports medicine practitioners frequently screen for bilateral strength asymmetries, flexibility, and functional capacity to identify potential issues (Wrona et al., 2023). As a result, assessing biomechanical aspects of jumping and landing has become essential in elite athlete programs. With this in mind, technological advancements have greatly improved the way athletic performance is assessed. Recent innovations allow for the evaluation of athlete abilities in laboratory settings with higher accuracy (Zare Mojtahedi et al., 2024). Among these, the countermovement jump (CMJ) test using dual force plates has become a standard method to assess lower-limb performance and asymmetry (Li & Xu, 2021). Countermovement jump (CMJ) measurement on a dual force plate system is possible evaluation of performance athletes and asymmetry during movement (J. McMahon et al., 2017). Notably, high asymmetry in CMJ has been associated with increased injury risk (Donahue et al., 2021).

CMJ testing, conducted without external loads, is widely used to evaluate jumping ability and muscle strength (Raya-González et al., 2021). It is commonly used to evaluate jumping performance (Cormie et al., 2010) and identify muscle strength and performance differences between sexes for exercise program development (Sarvestan et al., 2020). Additionally, CMJ helps monitor neuromuscular readiness, fatigue, and recovery (Laffaye et al., 2014). Research indicates that male athletes produce higher peak concentric power and greater eccentric and concentric impulses compared to female athletes during CMJ tests (Gathercole et al., 2015). The differences in body composition between males and females significantly influence performance (Kavanaugh et al., 2018). Women are 27% weaker than men in lower body strength, this is because men have longer muscles in the vastus lateralis (Rice et al., 2017). Maximal strength is governed by neuromuscular and morphological factors, including muscle thickness (Bartolomei et al., 2021). Hormonal factors such as testosterone also contribute to men's advantage in strength and endurance Hormonal factors such as testosterone also contribute to men's advantage in strength and endurance (Bartolomei et al., 2022), ranging from body composition, aerobic capacity, and hormonal differences (Thibault et al., 2010). The hormone testosterone in men has physiological advantages in strength and endurance

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(Roberts et al., 2021). Anthropometric measurements and task-specific factors further influence strength disparities and affect an athlete's development (Tounsi et al., 2018).

Despite the importance of explosive lower-body power in basketball, there is limited research focusing specifically on gender differences in CMJ performance among elite basketball players. Most existing studies focus on general populations or athletes from various sports, limiting sport-specific insights. Therefore, a clear research gap exists in understanding sex-specific performance characteristics in elite basketball. This study aims to examine gender-based differences in countermovement jump (CMJ) performance among elite basketball athletes. By focusing on a sport-specific population, the findings of this study will contribute to designing evidence-based strength and conditioning programs that are tailored to each gender. This approach not only aims to optimize performance but also to support injury prevention and long-term athlete development (Dos Santos Andrade et al., 2017).

Methodology

Research Design

Data were analyzed using Minitab 21 software (USA). Normality was assessed using the Shapiro-Wilk test. An independent t-test was conducted to compare the differences between male and female athletes in body composition and countermovement jump performance. Pearson correlation was used to examine the relationship between BMI, PBF, and jump performance. For non-normally distributed data, Mann-Whitney U Test and Spearman correlation were applied. Statistical significance was set at $p < 0.05$.

Study Participants

This study employed a cross-sectional observational design to assess lower-limb muscle power in elite junior basketball players. Subjects included purposively selected male and female elite junior athletes (n=24). Participants were selected based on inclusion criteria: (1) aged ≤19 years, (2) no lower extremity injuries, and (3) provincial-level minimum performance. Exclusion criteria: (1) athletes not adhering to training protocols within one month before testing. After selection, 12 male and 12 female athletes participated in the study. Ethical approval was granted by the ethics committee (763/KEP.01/UNISA-BANDUNG/V/2024).

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Study Organization

Participants filled out initial selection forms and underwent body composition testing using a Bioelectrical Impedance Analysis (BIA) device (InBody 270, Seoul, South Korea). Lower-limb muscle power was assessed through a Countermovement Jump (CMJ) test, analyzing parameters such as jump height, peak power, and flight time. Performed using ForceDecks FD Lite 400 (Vald Performance, Queensland, Australia). Each athlete completed three repetitions, with the best attempt used for analysis, following a Standard Operating Procedure:

1. Baseline Measurement: Athletes stood on the platform for body weight assessment.
2. Countermovement Jump Execution: Maintaining hands on hips, athletes performed a squat, jumped maximally, landed in a squat position, and returned to the starting stance.

Results

The 24 elite junior basketball players, the results of anthropometric studies showing age, height, weight, Body Mass Index (BMI), and Precent Body Fat (PBF) can be seen in Table 1. Male athletes were slightly older (17.8 ± 0.8 years) than females (16.8 ± 0.8 years), and they were significantly taller, heavier, and had lower PBF. These findings indicate gender differences in physical profiles among young athletes.

Table 1. Descriptive results of the body composition

Variable	Male (n=12)	Female (n=12)	*p*
	Mean ± SD		
Age	17.8 ± 0.8	16.8 ± 0.8	0.007*
Height (cm)	187.4 ± 8.7	172.8 ± 4.6	0.001*
Weight (kg)	79.9 ± 15.1	63.4 ± 7.9	0.001*
BMI (kg/m ^{2})	22.6 ± 3.1	21.2 ± 2.2	0.056
PBF (%)	9.6 ± 3.3	20.2 ± 5.1	0.001*

Note. BMI = Body Mass Index; PBF = Percent Body Fat

Result of countermovement jump the performance of male athletes in Table 2 shows that eccentric 1813.6 ± 336.9 N, concentric 1937.0 ± 382.0 N, peak power 4644.0 ± 839.0, jump height (FT) 41.1 ± 4.5 Cm, flight time 577.8 ± 31.7 ms, and result of

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countermovement the performance of female athletes shows that eccentric 1400.3 ± 181.2 N, concentric 1438.0 ± 171.0 N, peak power 2749.0 ± 298 W, jump height (FT) 25.5 ± 2.9 Cm, flight time 455.2 ± 26.0 ms. Male athletes consistently outperformed females in all measures of countermovement jump except for jump height, where the difference was not statistically significant**.** It is known that around 40% - 70% of women's muscle strength is lower than men (Miyashita & Kanehisa, 1979). Gender differences play an important role in jumping, male athletes are able to jump higher than female athletes (Wyon et al., 2006).

Table 2. Descriptive results of the CMJ

Variable	Male	Female	*p*
	Mean ± SD		
Eccentric Peak Force (N)	1813.6 ± 336.9	1400.3 ± 181.2	0.049
Concentric Peak Force (N)	1937.0 ± 382.0	1438.0 ± 171.0	0.001
Peak Power (W)	4644.0 ± 839.0	2749.0 ± 298	0.001
Jump Height (FT) (cm)	41.1 ± 4.5	25.5 ± 2.9	0.001
Flight Time (ms)	577.8 ± 31.7	455.2 ± 26.0	0.001

Note. FT = Flight Time

Apart from that, in Table 3, this study also shows the correlation between BMI and PBF with countermovement jumps performance, BMI was not strongly correlated with CMJ performance except for jump height (FT) and flight time, suggesting its limited predictive value for athletic success. Conversely, PBF showed a strong negative correlation with all measures of jump performance, indicating that lower PBF enhances athletic outcomes. This reinforces the importance of monitoring body composition, particularly PBF, in elite athletes (Abidin & Adam, 2013).

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Table 3. Correlation Results

Variable	Mean ± SD	*p*
PBF (%) Eccentric (N)	14.9 ± 6.8 1606.9 ± 338.5	0.009*
PBF (%) Concentric (N)	14.9 ± 6.8 1687.3 ± 385.3	0.001*
PBF (%) Peak Power (W)	14.9 ± 6.8 3696.5 ± 1147.5	0.001*
PBF (%) Jump Height (FT) (cm)	14.9 ± 6.8 33.3 ± 8.8	0.001*
BMI (kg/m2) Flight Time (ms)	21.9 ± 2.7 516.5 ± 68.8	0.046*
PBF (%) Flight Time (ms)	14.9 ± 6.8 516.5 ± 68.8	0.001*

Discussion

This study has identified countermovement jump basketball athletes and conducted a comparison across genders, our analysis revealed some interesting results. As expected, male athletes demonstrated higher jumping ability, driven by greater peak power and force production. Gender-based physiological differences, such as muscle mass and body composition, contribute significantly to these disparities. Interestingly, PBF was found to be a stronger predictor of CMJ performance compared to BMI. Lower PBF was consistently associated with better jump outcomes, while BMI showed limited correlation. This finding highlights the inadequacy of BMI as a standalone measure for evaluating athletic performance, especially in sports requiring explosive power. The ability to jump in the sport of basketball is one of the important components towards success in the game. The results that have been presented from the jumping ability of male and female athletes are more or less the same as expected and there are no significant differences between male and female athletes, but in terms of CMJ test results for men are around 20%-25% higher than women, similarly, several studies also state that CMJ test results for men are around 25%-27% higher than women (Laffaye et al., 2014). CMJ measurements involve a smooth and immediate transition between loading phase flexion and takeoff phase extension. It was found that in men, peak strength was the most accurate

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predictor of jump height, regardless of type. In women, peak strength was found to be the most accurate predictor of CMJ height (Laffaye et al., 2014).

The reason for the similar strength demonstrated by both sexes may reflect the different jumping strategies used by each group. For example, as women show less Center of Mass (COM) displacement during the eccentric and concentric phases of a jump reflecting a stiffer lower extremity strategy, it has been previously described that women and men have different stiffness strategies when jumping (J. J. McMahon et al., 2012). And in this study it has been stated that athletes' jump height is still categorized as very low with an average of 41cm for male and 25cm for female, compared to previous studies which also stated that CMJ height in the range of 36-45cm is still categorized as low (Riggs & Sheppard, 2009). Therefore, in this study, elite junior basketball athletes were still categorized as very low, even though basketball athletes need jump height to rebound and block opponents during the match, so from this research coaches and athletes benefit from being able to evaluate athletes. In addition to jump height, landing in basketball is also considered very important, because landing with a jump is a common occurrence in basketball players and can cause various injuries. Evidence shows that the majority of basketball injuries (66% to 58%) occur in the lower extremities (Asadpour & Norasteh, 2024). Improving jumping ability is necessary for a basketball athlete, because jumping is an important indicator during a match. So, every athlete needs to improve the ability of their leg muscles to support their performance.

The work–energy–power relationship makes it inevitable that greater joint powers result in more positive work done and greater total body kinetic energy and mass centre vertical velocities at take-off and indicator of maximal capabilities of the knee extensor muscle, a greater peak isometric knee extension torque enables greater joint torques and powers to be produced during the CMJ (McErlain-Naylor et al., 2014). The height of the CMJ also depends on the strength of the lower extremity muscles. Realizing the importance of strength in the lower limbs, body composition also has a positive relationship with athlete performance (Boone, 2015). While these characteristics of body composition and physical ability can predict success in young players and help in identifying athlete talent, determining the correlation between physical variables and body composition and athlete success remains a challenge (Aouichaoui et al., 2024). This

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study found that athletes with lower PBF performed better in jumping results (CMJ), in contrast to BMI results in that there was no strong significance with CMJ results, this occurred possibly because BMI is not an accurate measure for measuring fat and muscle body.

These results suggest a need for targeted training interventions to improve leg strength and explosive power, particularly for female athletes. The importance of knowing the performance of the athlete's jump height and body composition is very important in order to maximize performance during the competition. Overall, this study provides valuable insights for coaches and trainers, emphasizing the need to monitor PBF and implement strength-focused training regimens to optimize performance and prevent injuries. Basketball itself also predominantly uses lower body extremities such as rebounding, cutting, and step ups. However, this study has certain limitations. The small sample size may limit the generalizability of the findings to a broader population. Additionally, the cross-sectional design prevents conclusions about causality between body composition and jump performance. Future research should incorporate longitudinal studies and larger sample sizes to strengthen these findings and explore the effects of specific training interventions on performance outcomes.

Conclusion

The findings of this study show that male and female athletes have differences in body competition and performance results from countermovement jumps. The correlation results between BMI and PBF with countermovement jump show that BMI and countermovement jump do not have a significant correlation except for Jump Height (FT) and Flight Time, while the correlation between PBF and countermovement jump shows that there is a strong correlation, except for Jump Height (FT) Relative Peak Landing Force. The further research will be collected more subjects and senior basketball players and this research can also increase the efficiency of exercise intervention exploration strategies such as: muscle strength training, plyometrics, and agility, to the regular use of force plates to monitor fatigue more effectively as injury prevention to improve the performance of elite junior basketball athletes. Besides that coaches, medical personnel and sports researchers can conduct further research and provide individual training

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programs based on muscle strength results so that athletes can increase and improve their leg muscle strength capabilities.

Acknowledgment

Thank you for Universitas Negeri Surabaya who funding this research and KineticX Lab Sports Science who support us.

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