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*Original article*

# *Anthropometric index and its relationship with vertical jumps and muscular power in basketball players*

[ *Índice antropométrico y su relación con los saltos verticales y la potencia muscular en basquetbolistas*]

[*Índice antropométrico e sua relação com saltos verticais e potência muscular em jogadores de basquete]*

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**Abstract**

**Introduction:** 3x3 basketball has grown in popularity in recent years. Its intense format demands strength and muscle power. Vertical jumps are essential in various game actions such as blocking, shooting, and recovering the ball.
**Objective:** To analyze the anthropometric status and its relationship with the body mass index, as well as the vertical jump capacity and muscular power in 3x3 university basketball players from Central and South America.

**Materials and methods:** A descriptive, cross-sectional, and correlational study was conducted. Forty-eight basketball players (26 men and 22 women) aged 18 to 24 from eight countries were evaluated. A Tanita scale, a SECA height rod, and an AXONJump contact platform were used. The jumps used were: Squat Jump, Countermovement Jump and Abalakov jump.

**Results:** The average weight for men was 85.8 kg and for women 64.0 kg; the average height for men was 1.85 m and for women 1.66 m. The BMI was 25.0 kg/m² and 23.0 kg/m² for men and women, respectively. Jump height and squat power were Jump: Men 32.4/cm with 2530w and Women 21.7/cm with 1340w, Countermovement Jump: men 33.5/cm with 2587w and women 23.9/cm with 1209w and Abalakov jump: men 40.9/cm with 2961w and women 26.1/cm with 1451w.

**Conclusions:** Male players perform better in both height and power. The body mass index suggests that greater muscle mass and less fat mass favor muscle power. Furthermore, age influences the decline in jumping height and power.

**Keywords:** anthropometry, body mass index; muscle power; vertical jumps.

**Resumen**

**Introducción**: el baloncesto 3x3 ha crecido en popularidad en los últimos años, su formato de juego es muy intenso y demanda fuerza y potencia muscular. Los saltos verticales son fundamentales en diversas acciones de juego como bloqueos, lanzamientos o recuperación de balón.

**Objetivo**: analizar el estado antropométrico y su relación con el índice de masa corporal, así como la capacidad de salto vertical y la potencia muscular en basquetbolistas universitarios 3x3 de Centroamérica y América del Sur.

**Materiales y métodos**: se realizó un estudio descriptivo transversal y correlacional. Se evaluaron 48 basquetbolistas (26 hombres y 22 mujeres) de 18 a 24 años de 8 países. Se usó una balanza Tanita, tallímetro SECA, plataforma de contacto AXONJump. Los saltos usados: Squat Jump, Countermovement Jump y Abalakov jump.

**Resultados:** el peso promedio para los hombres 85.8/ kg y las mujeres 64/ kg; la estatura promedio fue en hombres 1.85/ m y mujeres 1.66/ m. El IMC fue 25.0 kg/m² y 23.0 kg/m² para hombres y mujeres, respectivamente. La altura de los saltos y la potencia Squat Jump: hombres 32.4/ cm con 2530w y mujeres 21.7/ cm con 1340w, Countermovement Jump: hombres 33.5/ cm con 2587w y mujeres 23.9/ cm con 1209w y Abalakov jump: hombres 40.9/ cm con 2961w y mujeres 26.1/ cm con 1451w.
**Conclusiones**: los jugadores masculinos presentan mejores resultados tanto en altura como potencia. El índice de masa corporal permite entender que a mayor masa muscular y menos masa grasa favorece a la potencia muscular. Además, la edad influye en la disminución de la altura y potencia del salto.

**Palabras clave**: antropometría, índicede masa corporal; potencia muscular; saltos verticales

**Resumo**

**Introdução**: O basquete 3x3 tem crescido em popularidade nos últimos anos, seu formato de jogo é muito intenso e exige força e potência muscular. Os saltos verticais são essenciais em diversas ações do jogo como bloquear, lançar ou recuperar a bola.
**Objetivo**: analisar o estado antropométrico e sua relação com o índice de massa corporal, bem como a capacidade de salto vertical e a potência muscular em jogadores de basquete universitário 3x3 da América Central e do Sul.
**Materiais e métodos**: foi realizado um estudo descritivo, transversal e correlacional. Foram avaliados 48 jogadores de basquete (26 homens e 22 mulheres) com idades entre 18 e 24 anos de 8 países. Foram utilizados balança Tanita, estadiômetro SECA e plataforma de contato AXONJump. Os saltos utilizados: Squat Jump, Countermovement Jump e Abalakov jump.
**Resultados**: peso médio para homens 85,8/kg e mulheres 64/kg; A altura média foi de 1,85/m nos homens e 1,66/m nas mulheres. O IMC foi de 25,0 kg/m² e 23,0 kg/m² para homens e mulheres, respectivamente. A altura dos saltos e potência Squat Jump: homens

32,4/cm com 2530w e mulheres 21,7/cm com 1340w, Salto de Contramovimento: homens 33,5/cm com 2587w e mulheres 23,9/cm com 1209w e Salto Abalakov: homens 40,9/cm com 2961w e mulheres 26,1/cm com 1451w.

**Conclusões**: os jogadores do sexo masculino apresentam melhores resultados tanto em altura como em potência. O índice de massa corporal permite-nos compreender que maior massa muscular e menor massa gorda favorecem a potência muscular. Além disso, a idade influencia na diminuição da altura e potência do salto.

**Palavras-chave:** antropometria, índice de massa corporal; força muscular; saltos verticais.

## *Introduction*

The 3x3 basketball modality has achieved great popularity in recent years, in addition to having been officially included as part of the Tokyo 2020 Olympic Games, unlike the 5x5 modality its game format is more intense (Andrianova *et al.,* 2021), also involves high motor coordination, changes of rhythm with continuous changes of direction, and repeated jumping in place or while running (Soto, 2023). Therefore, the modern player must have high physical capacity and muscular power for jumping that also allows him to overcome the demands of the game (Domínguez *et al.,* 2023).

These demands will depend on motor coordination as a basis, which is related to the quality of the development of the central nervous system to manage motor actions or responses through jumps (Gutiérrez, *et al.,* 2021) essential for blocking, throwing or recovery, actions present in much of the dynamics of the game and that depend directly on the strength and muscular power generated by the lower limbs (Sansone. *et al.,* 2023; Saeterbakken *et al.,* 2022; Batalla *et al.,* 2022) and also muscle recruitment resulting from training. Therefore, a lower predominance of muscle mass and a higher fat mass in body composition will directly influence low physical fitness (Ramos, *et al.,* 2021). A decrease in strength is not only associated with low physical performance, but is also a reference for health and quality of life, considering that the university population in recent years

has been reporting low levels of muscular fitness (López *et al.,* 2021 and Méndez *et al.,* 2021).

Finally, the objectives of this study were: (1) to analyze anthropometric status and its relationship with body mass index (BMI); and (2) to evaluate vertical jump capacity and its impact on muscular power in 3x3 college basketball players from Central and South America. An indirect exploration will be made of the behavior of the body mass index and its influence on vertical jump capacity, as well as its relationship with muscular power in this population according to gender and a comparison with other research at the professional and elite levels.

## *Materials and methods*

### *Design*

A descriptive, cross-sectional study with a correlational approach was conducted. Mathematical, empirical, and statistical methods were used. The sample consisted of university 3x3 basketball players from Central and South America.

### *Participants*

They were selected non-probabilistically (10% raffle method), which consisted of 48 subjects: 26 men (54.17%) and 22 women (45.83%), aged between 18 and 24. The athletes came from university national teams from 8 Central and South American countries (Argentina, Brazil, Chile, Colombia, Costa Rica, El Salvador, Mexico, and Peru). These selected participants participated in the university games held in Lima, Peru, in April 2022. University athletes who reported no motor problems or injuries participated in the study. Subjects who had suffered a sports injury in recent weeks were excluded.

*Procedure and instruments*

Data collection took place in the sports biomechanics laboratory located at the San Ignacio de Loyola University, Pachacamac campus (Lima). Testing was conducted in the morning between 8:00 and 11:00 a.m. for five consecutive days, with 60-minute shifts per team. The athletes attended in sportswear (shorts, polo shirt, and sneakers). An anthropometric assessment was performed first, followed by strength tests.

Decimal age was calculated by the difference between the age at birth and the day of evaluation. Basic anthropometric variables were measured according to the protocol of the International Society for the Advancement of Kinanthropometry. Weight was recorded in (kg) on a calibrated digital scale (Tanita, model Innerscan Pro RD-545HR) with a precision of 0.1/kg and height in (cm) on a portable stadiometer (SECA model 213) with a precision of 0.1 cm. The evaluation procedure was carried out by an experienced anthropometrist.

Before the jumps, a 10-minute warm-up was performed, three attempts were made for each jump, and a 40-second rest period was established between each jump for recovery. The highest height reached (best result in cm) was recorded. Height data was obtained using an AXONJump contact platform. Software 4.02. The jumps used to assess physiological and neuromuscular capacities were: Squat Jump (SJ), Countermovement Jump (CMJ) and Abalakov jump (ABK).

Squat Jump (SJ): This test assesses explosive strength and concentric muscle activation patterns. Start in a stance with your knees bent at 90°, your torso straight, and your hands placed on your waist.

Countermovement Jump: This test assesses explosive and elastic strength (reuse of elastic energy). The muscle activation modality is concentric and eccentric. Start standing with your hands on your waist, then quickly flex and extend your knees to a 90° angle and push off as quickly as possible in the vertical component.

Abalakov (ABK): This test assesses explosive and elastic strength (elastic energy reuse) and arm coordination. It begins with the subject standing with their hands in front of them, followed by a rapid knee flexing and extending motion, accompanied by a back-and-forth motion of the hands, reaching a 90° angle and propelling the subject forward as quickly as possible in the vertical component.

The statistical analysis was performed using the free software R version 4.4.1, which consisted of two parts: descriptive analysis and inferential statistics. To compare the anthropometric index, vertical jumps, and muscle power, four studies were used. Their content focused on aspects of physical performance and the development of reactive strength and jumping ability in university 3x3 basketball players with players from the junior, university, and professional categories.

## *Results and discussion*

To obtain the results, the body mass index (BMI) was used, which was calculated using the formula: kg/m² and for the power data, using the formula: Peak Power (W) = 60.7 * (jump height [cm]) + 45.3 * (body mass [kg]) - 2055 (Sayers et al., 2014). This formula uses as reference data the jump height and the subject's body mass, a relevant aspect in basketball, because weight and explosiveness directly influence performance. While for the results of the jumps the protocol described by Bosco (1996. Pp. 72-87) was used, a protocol that is widely used in research that requires high muscular explosiveness and that allows obtaining reliable data in the analysis of vertical jumps, essential considerations in the development of this study that seeks to relate the anthropometric index, vertical jumps and muscular power.

Regarding the age variable, the median in men was 21.1 and in women 21.3 years, this data indicates that there is no statistically significant difference between men and women (p- value: 0.591).

Regarding the anthropometric variable, for weight: a significant difference is evident between men and women (p- value: 1.19e-08). The average weight in men was 85.8 kg (SD: 11.7) and in the case of women the weight is 64 kg (SD: 9.83). Height: men measure on average 1.85 m (SD: 0.0813) and women 1.66 m (SD: 0.0763), the results also indicate a significant difference in this variable (p- value: 1.38e-10). The Body Mass Index (BMI) of men has an average of 25.0 kg / m², while women 23.0 kg / m². The p-value: 0.0258 suggests a significant difference, but not as marked as weight or height. These differences, especially in body mass and BMI, can influence jumping ability and vertical power, an important factor in basketball.

Regarding the variable height of the jumps and the power for the Squat Jump, Countermovement Jump and Abalakov Jump, there are notable differences between men and women, similar values are observed in the power results, with the result obtained by men being higher for both variables (Table 1).

***Table 1.*** *- Anthropometric characteristics, explosive strength and power of the sample*

| Indicators | Men | | Women | | Difference of means test | |
|---|---|---|---|---|---|---|
| | X | OF | X | OF | Statistics | P value |
| Age (years) | 21.1* | 1.92 | 21.3* | 2.01 | 312 | 0.591** |
| **Anthropometry** | | | | | | |
| Weight (kg) | 85.5 | 11.7 | 64 | 9.83 | 47.91 | 1.19e-08 |
| Height (m) | 1.85 | 0.0813 | 1.66 | 0.0763 | 67.66 | 1.38e-10 |
| BMI (k/m ²) | 25.0 | 3.39 | 23.0 | 2.46 | 5308 | 0.0258 |
| **Explosive force** | | | | | | |
| SJ (cm) | 32.4 | 7.19 | 21.7 | 4.03 | 38.05 | 1.62e-07 |
| Maximum vertical power of the SJ(w) | 25.30 | 516 | 1340 | 307 | 89.85 | 2.17e-12 |
| CMJ(w) | 33.5 | 7.84 | 23.9 | 3.73 | 27.79 | 3.52e-06 |
| Maximum vertical power of the CMJ (w) | 25.87 | 636 | 1209 | 281 | 88.42 | 2.77e-12 |
| ABK (cm) | 40.9 | 7.84 | 26.1 | 3.73 | 57.17 | **1.32e-09** |
| Maximum vertical power of the ABK (w) | 2961 | 636 | 1451 | 281 | 78.29 | 1.72e-11 |

* For age, the median and the IQR were used because it did not have a normal distribution.

** For age, the Wilcoxon test was used (differences in medians

The results of the relationships show a moderate positive correlation between age and BMI for men, suggesting that as age increases, so does BMI. However, the confidence interval includes zero, indicating that this relationship is not statistically significant. For

women, a weak negative correlation is found, suggesting that BMI decreases slightly with age, although this is also not statistically significant due to the confidence interval.

Age and vertical jumps show a negative relationship in both men and women. In men, a decrease in squat jump height is observed. Jump (r=−0.407) and Countermovement Jump (r=−0.368), although the relationship is weaker in women. Regarding maximum power, correlations are generally low and non-significant, except in the Abalakov (women), where a moderate negative correlation is detected (r=−0.429). These data suggest that, as age increases, performance in vertical jumps tends to decline, being most noticeable in the Squat. Men's Jump and the Abalakov jump for women (Table 2).

***Table 2.*** *- Relationship between age and BMI, jump height and power*

| Indicators | r | Men's age | r | Age women |
|---|---|---|---|---|
| | | Int . trust | | Int . trust |
| BMI (k/m ²) | 0.33 | [-0.0628, 0.638] | -0.236 | [-0.598, 0.206] |
| YES (cm) | -0.407 | [-0.0686, -0.0235] | -0.227 | [-0.592, 0.215] |
| Maximum vertical power of SJ(w) | -0.317 | [-0.0627, 0.0804] | -0.238 | [−0.600, 0.204] |
| CMJ(w) | −0.368 | [−0.0661, 0.0223] | −0.342 | [−0.667, 0.0931] |
| Maximal vertical CMJ power (w) | 0.156 | [−0.246, 0.513] | −0.069 | [−0.477, 0.363] |
| BP (cm) | −0.261 | [−0.589, 0.141] | −0.429 | [−0.720, −0.0085] |
| Maximum vertical power of the ABK(w) | −0.211 | [−0.553, 0.192] | −0.147 | [−0535, 0.293] |

For the comparative results between the anthropometric profile, height and power of jumps in men, it is observed that the age of the study is lower than that of the players of the 3x3 world championship (2016) and professional players 1 between 4 and 8 years old, in that same line the weight and height. Regarding the height and power of the squat jumps Jump, Countermovement Jump and Abalakov Jump the study group presents the lowest values (<40/cm) (Table 3).

***Table 3.*** *- Comparison of anthropometric index, height and jumping power in 3x3 male basketball players*

| Men's indicators | Study (3x3) | | CM (3x3) | | Professional 1 | | Professional 2 | | Youth elites | |
|---|---|---|---|---|---|---|---|---|---|---|
| | x | OF | x | OF | X | OF | X | OF | X | OF |
| Age (years) | 21.1 | 1.92 | 29.4 | 5.4 | 25.8 | 4.3 | 19.4 | 3.5 | 17.3 | 0.45 |
| Weight (kg) | 85.5 | 11.7 | 95.2 | 10.8 | 89.2 | 3.3 | 77.4 | 11.4 | 87.8 | 9.5 |
| Estatura (m) | 1.85 | 0.08 | 194.7 | 7.4 | 194 | 5.5 | 182.9 | 6.1 | 196.4 | 4.8 |
| IMC (k/m²) | 25.0 | 3.39 | - | - | - | - | 23.1 | 2.6 | - | - |
| SJ (cm) | 32.4 | 7.19 | - | - | 46.1 | 4 | - | - | - | - |
| Maximum vertical power of SJ(w) | 2530 | 516 | - | - | - | - | - | - | - | - |
| CMJ(w) | 33.5 | 7.84 | - | - | 44.3 | 4.3 | 40.4 | 5.04 | 41.6 | 7 |
| Maximum vertical power of the CMJ (w) | 2587 | 636 | - | - | - | - | 3874.4 | 639.3 | - | - |
| ABK (cm) | 40.9 | 7.84 | - | - | - | - | | | 47.1 | 8.2 |
| Maximum vertical power of the ABK (w) | 2961 | 636 | - | - | - | - | - | - | - | - |

*Montgomery and Maloney (2018), CM (3x3), Cabarkapa et al. (2023), Professional 1, Pojskiæ , et al. (2017), Professional 2, Calleja, et al. (2017) Youth Elite*

For the comparative results in women, it is observed that the age of the study is younger than that of the players in the 3x3 World Championship (2016) and older than that of the players in the elite study. Weight and height are lower in the study. Regarding height and jump power alone, the Countermovement could be compared. Jump with the players in the Elite study, which shows a significant difference (+10/cm). Power follows the same line (Table 4).

***Table 4.*** *- Comparison of anthropometric index, height and jumping power in female 3x3 basketball players*

| Men's indicators | Study (3x3) | | CM (3x3) | | Elite | |
|---|---|---|---|---|---|---|
| | **X** | OF | X | OF | X | OF |
| Age (years) | 21.3 | 2.01 | 25.7 | 4.5 | 18 | 2 |
| Weight (kg) | 64 | 9.83 | 68.7 | 9.2 | 76.2 | 7.6 |
| Height (m) | 1.66 | 0.08 | 178.1 | 7.5 | 1.85 | 0.09 |
| BMI (w / ᵐ | 23.0 | 2.46 | - | - | - | - |
| SJ (cm) | 21.7 | 4.03 | - | - | - | - |
| Vertical maximum power of the SJ(w) | 1340 | 307 | - | - | - | - |
| CMJ(w) | 23.9 | 3.73 | - | - | 39 | 0.05 |
| Maximal vertical CMJ power (w) | 12.09 | 281 | - | - | - | - |
| ABK (cm) | 26.1 | 3.73 | - | - | - | - |
| Maximum vertical power of the ABK (w) | 1451 | 281 | - | - | - | - |

*Montgomery and Maloney (2018), CM (3x3), Legg et al. (2017), Elite*

According to the results obtained, significant differences are evident in anthropometric variables and jumping ability between the sexes. From this, it can be stated that greater height and weight, in the case of men, provide an advantage in generating greater strength and power, as has been seen in similar studies (Rodríguez *et al.,* 2017); Uysal *et al.,* 2023; Janicijevic *et al.,* 2020 and Mancha *et al.,* 2021); in addition, muscle elasticity is a key factor for better jumping ability, that is, the use of elastic energy through the vertical jump as required by basketball due to its game nature (Reinoso *et al.,* 2022; Aztarain *et al.,* 2022; Garrido *et al.,* 2023 and Blandon , 2023). This can be observed in the results obtained in the Squat jumps Jump, Countermovement Jump and Abalakov Jump, where men achieved higher heights compared to women, similar results were also found in other studies and even point to a difference of 10.3, ±0.6 cm approximately 33% (Kozinc *et al.,* 2020; Fernandes *et al.,* 2020; Haugen *et al.,* 2020)

Body mass index (BMI) also showed a significant relationship with jump height and power performance, although not as significant as weight or height. However, a higher BMI may be related to lower vertical jump performance due to the predominance of non-functional body mass; that is, a high percentage of muscle mass and low adipose tissue may tend to lead to better jump height performance (Corredor *et al.,* 2023; Tauda, 2024). Competitive sports require more pronounced muscle development than the average person. Complementing this concept, greater muscle mass in athletes should be linked to a lower percentage of fat mass, while maintaining the same weight (Romero *et al.,* 2024; González *et al.,* 2020; Castañeda *et al.,* 2020).

Regarding muscle power in Squat jumps Jump, Countermovement Jump and Abalakov Jump, the data indicates a greater capacity for muscular power in men compared to women. Similar results are shown in another study for the Countermovement Jump in which female players generate 3455 ± 496 W compared to male players who reach values of 4570 ± 900 W (Duncan *et al.,* 2013), A similar case for the height of the Squat Jump and the Jump Countermovement between men and women, found statistically relevant differences in the height of the jumps ($p < 0.05$), with greater height in men (Kellis *et al.,* 1999). On the other hand, among the Squat jumps Jump and Countermovement Jump,

the CMJ test showed the strongest relationship with explosive power factor (r = 0.87), which is consistent with previous studies demonstrating men's ability to produce more power due to greater muscle mass and strength (Lacio et al., 2021). That is, peak power is often influenced by sex differences, regardless of strength levels (Rice, *et al.,* 2017) .

One aspect to highlight in the results obtained is that, as age increases, both men and women show a decrease in the height of their jumps and a similar result in terms of power, particularly in the Squat. Jump for men and in the Abalakov Jump for women, which is consistent with other studies indicating a progressive loss of muscle mass, a decrease in the ability to generate height, speed, strength and power as age increases (Ganse and Degens, 2021 and Garcia *et al.,* 2021), changes that favor a decline in performance. However, this loss was not statistically significant in all outcomes, so it can be assumed that age is not the only influencing factor in height, strength, and power in vertical jumps in this university population.

Finally, in comparison with other world-class, elite or professional basketball studies, it was shown that university basketball players in the 3x3 modality present a lower performance in vertical jumps and muscular power (Montgomery, 2018; Cabarkapa, 2023; Pojskiæ, 2015; Legg, 2017 and Calleja, 2018), these differences could be assumed due to the number of sessions, frequency and level of training, experience and competitive environment or differences in body composition. It should also be noted that the information to compare contexts with other university-level studies in the 3x3 modality is limited, which makes a better analysis difficult.

## *Conclusions*

This study provides a comprehensive view of the variables anthropometric index, vertical jump, and muscular power in South American 3x3 college basketball players, establishing the differences between the sexes. Male players' performance in both height and power is more prevalent than female players' performance. The results are similar to those in existing literature, which refers to the direct relationship between sex, weight,

and height, and their impact on physical performance in competitive and high-level sports.

The body mass index (BMI) also showed a significant relationship, although not as pronounced as weight and height. However, it does allow us to understand that, in terms of body composition, a greater prevalence of muscle mass and a low percentage of fat mass favors explosive strength and muscular power in sports. However, the BMI is not the appropriate indicator for determining body composition in competitive sports.

Regarding age, both men and women show a decrease in performance, with a decline in jump height and power. This is consistent with other studies showing a gradual loss of strength and power over the years due to the progressive loss of muscle mass. Although the data for this study do not suggest a significant relationship in all jumps and variables, other considerations such as sports experience, training and competition level, and differences in body composition or genetics that can also influence athletic performance should be taken into account.

On the other hand, when comparing the Anthropometric Index and the height and power results with other university studies of 3x3 basketball, including those at the world, elite, and professional levels, the data obtained are inferior. The evidence obtained suggests prioritizing more reactive training and a predominance of the elastic component in physical preparation, in addition to improving the selection of athletes based on their basketball body type. It should also be noted that the literature on university 3x3 results is limited and does not allow for direct comparison, highlighting the need for more studies at this level.

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***Conflict of interest*:**

The authors declare no conflicts of interest.

***Authors' contributions*:**

The authors have participated in the writing of the work and analysis of the documents.