Relationship between body composition, lower body power and grip strength

Relación entre la composición corporal, potencia del tren inferior y fuerza prensil

Candia-Sosa, KF[1FABC]; Candia-Lujan, R[2BC]; Acosta-Carreño RE[3CD]; Domínguez-Gavia NI[4CD]; Ortiz-Rodríguez B[5AC]

[1] Universidad Autónoma de Chihuahua, México, Kcandia@uach.mx
[2] Universidad Autónoma de Chihuahua, México, Rcandia@uach.mx
[3] Universidad Autónoma de Chihuahua, México, Rcarreno@uach.mx
[4] Universidad Autónoma de Chihuahua, México, Nidominguez@uach.mx
[5] Universidad Autónoma de Chihuahua, México, Bortizr@uach.mx

Responsibilities. (A Study design; B Data collection; C Manuscript drafting; D Statistical analysis; E Financial support; F Original idea and overall research coordination)

Corresponding author: Ramón Candia Lújan. Rcandia@uach.mx

ABSTRACT

This study analyzed the relationship between body composition and muscle function in 36 healthy young adults. Lean mass and fat mass were measured using bioelectrical impedance, jump power via a countermovement jump (CMJ) test, and grip strength with a dynamometer. Results revealed that lean mass was a significant predictor of greater grip strength (r²=0.641) and power (r²=0.345). In contrast, fat mass showed a negative correlation with jump height (r²= -0.543). It is concluded that higher lean mass is associated with improved strength and power, while a high body fat percentage impairs performance in explosive activities. These findings underscore the importance of optimizing body composition to enhance physical performance.

KEY WORDS: muscular function, body composition, physical performance

RESUMEN

Este estudio analizó la relación entre la composición corporal y la función muscular en 36 jóvenes sanos. Se midió la masa magra y grasa mediante bioimpedancia, la potencia de salto con un test de contramovimiento (CMJ) y la fuerza prensil con dinamometría. Los resultados demostraron que la masa magra es un predictor significativo de una mayor fuerza prensil (r²=0.641) y potencia (r²=0.345). Por el contrario, la masa grasa mostró una correlación negativa con

la altura del salto (r²= -0.543). Se concluye que una mayor masa magra se asocia con una mejor fuerza y potencia, mientras que un alto porcentaje de grasa corporal limita el rendimiento en actividades explosivas, resaltando la importancia de optimizar la composición corporal para el desempeño físico.

PALABRAS CLAVE: función muscular, composición corporal, rendimiento físico

INTRODUCTION

Body composition is the branch responsible for studying and quantifying the different components that make up the human body. Its analysis allows us to understand how the different elements that make up the organism are distributed and related. This area offers specific and complementary perspectives for the comprehensive study of the human body from its different levels of organization: atomic, molecular, cellular, tissue, and total body (1).

Focusing specifically on the tissue level, the physical assessment of body composition is based on a model that divides the body into four fundamental components: adipose tissue, skeletal muscle tissue, bone tissue, and residual tissue (2).

Various techniques are available to assess body composition (muscle, fat, bone, and residual mass), including computed axial tomography (CAT), nuclear magnetic resonance (NMR), dual-energy X-ray absorptiometry (DXA), air displacement plethysmography, anthropometry, and bioelectrical impedance (3).

The latter method estimates total body water, fat tissue, and muscle tissue. Its principle is based on the different electrical conductivity of body tissues, measuring the opposition (impedance) encountered by a low-intensity electrical current as it passes through the body (2).

Although these techniques quantify muscle mass as a general component, it is essential to understand that this is not a homogeneous tissue. There are three types of muscle tissue: skeletal, smooth, and cardiac (4).

Skeletal muscle is a voluntary contraction tissue attached to the skeleton that allows movement, posture, and thermogenesis. Its composition is given by a striated and multinuclear structure, functioning under the control of the somatic nervous system (5,6).

Muscle fibers, composed of 80% protein, are organized into thousands of myofibrils. These contain millions of actin and myosin myofilaments (70-80% of proteins), which are structured into sarcomeres, the fundamental contractile units. The contraction process begins with a nerve impulse that releases calcium from the sarcoplasmic reticulum. This calcium allows myosin to bind to actin, forming cross-bridges. The energy from ATP causes myosin to move, sliding the filaments and shortening the muscle fiber, which generates force (7).

This function is manifested and objectively evaluated through indicators such as grip strength and jump power, which act as windows into the state of the neuromuscular system. Performance in these tests is critically modulated by body composition: while greater lean mass is positively associated with grip strength and jump power by providing the necessary contractile substrate, excess fat mass, particularly when infiltrated into muscle tissue, acts as a disruptive factor. This excess lipid not only represents a mechanical overload that can hinder propulsion capacity, but also directly interferes with the contractile machinery and energy efficiency of muscle fiber (8,9).

This interference constitutes the pathophysiological basis of dynapenia, a condition characterized by loss of strength and functionality that can occur even with relatively preserved muscle mass. In its development, ectopic lipid accumulation in skeletal muscle plays a major role, with people with dynapenia having higher weight, BMI, and body fat index, which accelerates the deterioration of contractile function and the ability to generate force (10).

To better understand the impact of this deterioration, it is important to consider what is meant by muscle strength as the ability of a muscle or muscle group to generate tension and overcome external resistance. It is not only a morphological attribute but also the result of the integration of neural, architectural, and mechanical factors (11).

Grip strength and jump power are parameters that, in addition to assessing muscle strength and function, can be an indicator of overall health, a predictor of athletic performance, and a relevant clinical marker associated with functional independence (12–15).

MATERIALS AND METHODS

Sample

Participants were recruited from the Faculty of Physical Culture Sciences at the Autonomous University of Chihuahua. The final sample included 36 individuals (25 males and 11 females) with an average age of 18 years. The inclusion criteria for the study were as follows: healthy subjects who did not have any pathologies such as hypertension, type 1 or 2 diabetes, heart disease, among others, who were over 18 years of age; subjects with joint and/or muscle problems were not accepted.

Body composition measurement

The research participants were asked to come to the weight room at the Faculty of Physical Culture in the morning, wearing comfortable clothing, and their body composition was assessed before any other activity. The measurement was carried out with the Inbody 230 bioelectrical impedance equipment, following the instructions in the user manual provided by the manufacturer. During the procedure, the participant stood on the device without

wearing any metal objects such as bracelets, necklaces, or watches, as these could interfere with the readings. Bare feet were placed on the base of the impedance meter, ensuring full contact with the electrodes. The hands wrapped around the electrodes on the equipment's handles, avoiding pressure with the fingernails.

Counter movement jump (CMJ)

After measuring body composition, participants were instructed to warm up for 5 minutes on the device of their choice (treadmill or cycle ergometer). Next, measurements of extended leg length, height at 90º, and lever were taken according to the instructions in the My Jump Lab mobile app. Participants were then instructed on the correct technique for performing a counter movement jump, after which they were asked to perform two jumps, with the best jump being taken as the valid data (16).

Grip Strength

Finally, the subjects were asked to perform a grip strength measurement, which consisted first of adjusting the grip opening of the Takei 5401 dynamometer to the participant's preference. then, in a standing position, four maximum grips were performed with the arm fully extended, as this position allows for greater strength levels compared to sitting positions (17), two with the right arm and two with the left arm. The average of the four grips was taken as the measured data.

RESULTS

Statistical analysis

Statistical analysis was performed using Prism 9 software from GraphPad Software, LLC (Version 9.0.1). The Shapiro-Wilk statistical test was applied to verify the normality of the data. Data are reported as means and standard deviations for data with normal behavior, and as medians and interquartile ranges for data that do not have a normal distribution. The correlation of the variables of interest was obtained using Pearson's correlation for parametric data and Spearman's correlation for nonparametric data. The results were considered significantly related when the *p* value was <0.05 (two-tailed). Similarly, a linear regression was performed to describe the relationship between the variables of interest.

Table 1 summarizes the general characteristics of the sample. All variables followed a normal distribution, except for age, which was analyzed using nonparametric methods.

Table1. General characteristics of the total sample (n=36)

	Mean ± SD	Maximum	Minimum	Range
Age (years)	18.0 ± 0.3*	23.0	17	6
Weight (kg)	73.2 ±16.6	108.0	46.2	61.80
Height (cm)	170.8 ± 7.9	184.0	154.0	30.0
Lean mass (kg)	30.6 ± 6.9	42.8	18.4	24.40
Fat mass (kg)	18.8 ±9.8	40.1	3.6	36.5

*Data shown in medians and interquartile range; SD = standard deviation; cm = centimeters; kg = kilograms.

Regarding muscle function variables (Table 2), jump height did not follow a normal distribution and was therefore analyzed using nonparametric methods.

Table 2. Muscle function of the total sample (n = 36)

	Mean ± SD	Maximum	Minimum	Range
Grip strength (kg)	39.4 ± 10.1	66.4	24.8	41.60
Jump height (cm)	28.0 ± 13.7*	48.6	15.4	33.20
Max. power (Watts)	335.1 ± 133.1	621.0	106.0	515.0

*Data shown in medians and interquartile range; SD = standard deviation; cm = centimeters; kg = kilograms.

Table 3. Association between lean mass values and muscle function

Lean Mass	R^2	ß	95% CI	*p* value
Grip Strength	0.641	0.548	0.4052 - 0.6911	<0.0001**
Power	0.345	0.304	0.0150 - 0.0457	0.0003**
Jump Height	0.096	0.222	-0.0266 - 0.471	0.078

ß Slope value; **$p<0.001$

Table 3 shows that lean mass is a good predictor of **grip strength (r^2 = 0.641, p<0.0001)** and **power (**r^2 = 0.345, p = 0.0003**)** variables. Jump height, however, was not significantly related to lean mass.

Table 4. Association between fat mass values and muscle function

Fat Mass	R^2	ß	95% CI	*p* value
Grip Strength	0.028	0.167	-0.4711 - 0.1693	0.32
Power	-0.203	0.013	-0.5109 - 0.1516	0.25
Jump Height	-0.543	0.155	-0.7521 - 0.2364	0.001

ß Slope value; *$p<0.05$

Regarding fat mass (Table 4), linear regression analysis showed that jump height has a significant inverse correlation ($r^2 = 0.543$, $p = 0.001$). In terms of grip strength ($r^2 = 0.028$, $p = 0.32$) and power ($r^2 = 0.203$, $p = 0.25$), it was not a good predictor of these variables.

Figure 1 shows that lean mass has a significant correlation with grip strength ($r = 0.800$, $p<0.05$) and power ($r = 0.587$, $p<0.001$). There is insufficient evidence to make the same claim for jump height. Regarding fat mass and its relationship with muscle function variables, jump height ($r = -0.543$, $p<0.001$) is shown to be significantly and negatively associated. This suggests that a higher percentage of fat mass negatively affects jumping ability, while grip strength and power show no significant relationships in the sample studied.
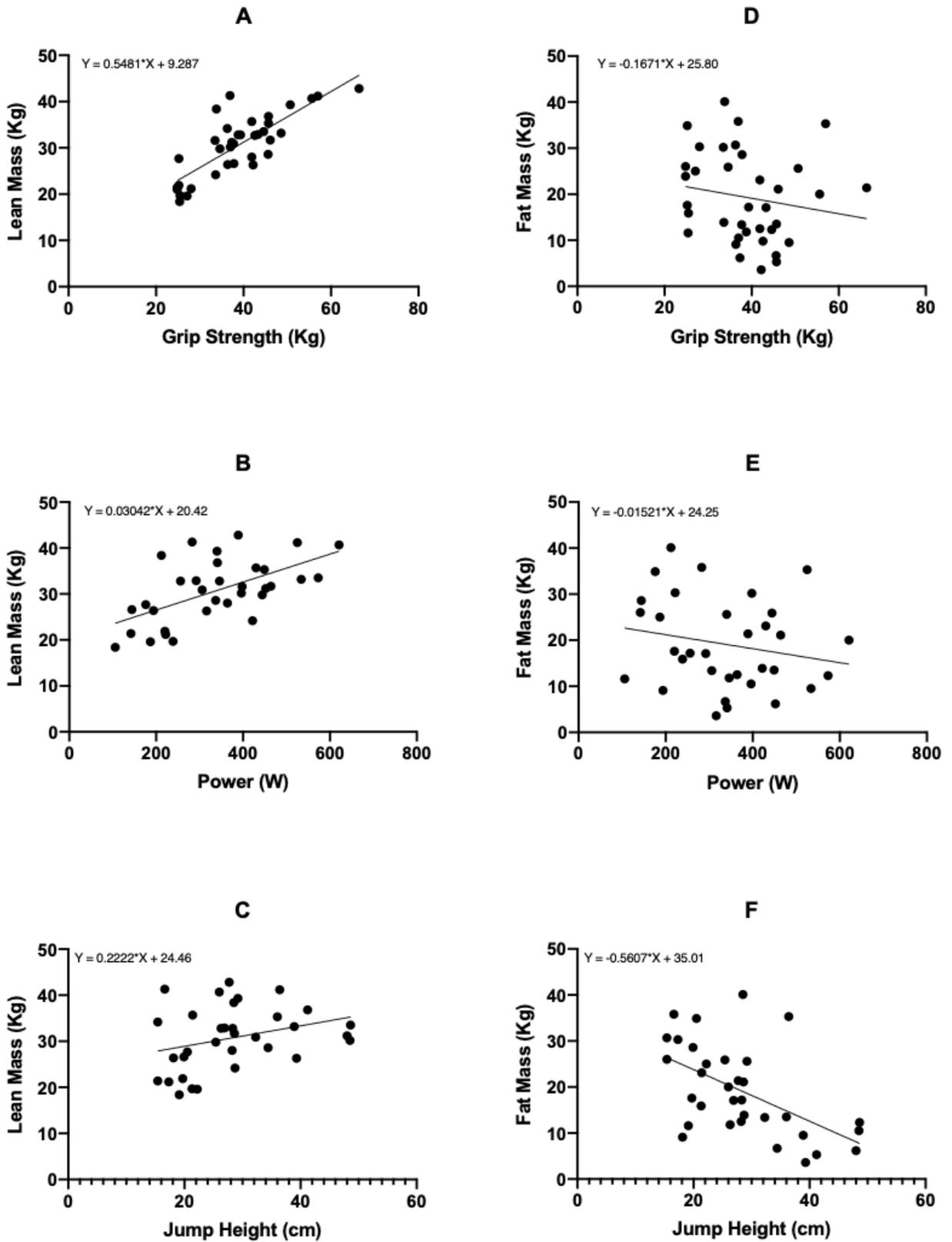
Figure1 Graphical association between variables: A, grip strength vs. fat mass; B, power vs. lean mass; C, jump height vs. lean mass; D, grip strength vs. lean mass; E, power vs. fat mass; F, jump height vs. fat mass

DISCUSSION

The results obtained in this study confirm the influence of muscle mass and fat mass on muscle function, specifically in variables such as grip strength, jump height, and power. These findings coincide with those reported by various authors who have studied the relationship between body composition and muscle performance in different sports and population contexts.

Morales et al. highlight a significant correlation between muscle weight and power in the lower limbs (r = 0.7) and upper limbs (r = 0.5) in men, as well as a very significant relationship between the power of both muscle groups (r = 0.8), which reinforces the idea that muscle mass is directly associated with explosive strength performance. In contrast, the data reported in women did not show significant relationships between these variables, suggesting possible physiological or training differences that influence the manifestation of power depending on sex (18).

Veliz et al. support these findings by showing that men have greater muscle mass and better performance in jump tests (SJ, CMJ, ABK) than women, who, on the contrary, have a higher percentage of fat mass. This difference in body composition between the sexes was also highlighted by Hernández and Cisterna, who found that male volleyball players had higher levels of muscle mass and lower body fat, factors that are directly linked to better results in counter-movement jumping and spike speed (19,20).

Complementarily, Benavides-Roca et al. found that specific anthropometric characteristics, such as calf diameter, are significantly related to jump power, reinforcing the importance of morphological parameters in physical performance. Likewise, Madroñero reported a high correlation between the percentage of muscle mass and the power obtained in the SJ and CMJ, indicating that a greater amount of muscle mass favors performance in this type of explosive action (21).

On the other hand, the study by Anthony et al. shows that a higher percentage of fat mass is negatively related to vertical jump performance, a finding that coincides with that observed in the present study, where an increase in fat mass seems to limit the expression of muscle power (22).

However, the results also reflect that these associations may vary according to gender and the sport practiced. Such is the case of the study by Akdogan et al., who reported no significant correlations between body composition and jump tests in male badminton players, while in female players, relevant associations were observed, especially with the percentage of fat in the legs (23).

Taken together, these findings support the conclusion that muscle mass has a positive influence on muscle function, especially in males, while higher fat mass may act as a limiting factor for explosive performance. The differences observed between genders and across sports disciplines suggest that

interventions to optimize physical performance should consider body composition in a specific and personalized manner.

LIMITATIONS AND FUTURE DIRECTIONS

The main limitation lies in the sample size (n=36), which, although adequate for preliminary analysis, is insufficient to extrapolate the results in a general way, as well as the limited evaluation of muscle function, where other important dimensions of muscle function, such as endurance and speed of force development, could be explored.

In order to further explore the findings reported here, the following is suggested for future research:

Incorporate more accurate methods for assessing body composition, such as dual-energy X-ray absorptiometry (DXA) or magnetic resonance imaging (MRI). These techniques would allow for more accurate quantification of muscle and fat mass, overcoming the limitations of electrical bioimpedance.

Expand the analysis of muscle function beyond jump power and grip strength. It would be valuable to include assessments of rate of force development (RFD) and muscle endurance tests, which would provide insight into neuromuscular performance.

REFERENCES

1. González Jiménez E. Composición corporal: estudio y utilidad clínica. Endocrinol Nutr. 2013 Feb;60(2):69–75.
2. Moreira OC, Alonso-Aubin DA, de Paz JA. Métodos de evaluación de la composición corporal: una revisión actualizada de descripción, aplicación, ventajas y desventajas. Arch Med del Deport [Internet]. 2015;32(6):387–94. Available from: https://archivosdemedicinadeldeporte.com/articulos/upload/rev1_costa_moreira.pdf
3. Bahamondes-Avila C, Cárcamo-Oyarzún J, Aedo-Muñoz E, Rosas-Mancilla M. Relación entre indicadores antropométricos regionales de masa muscular y potencia de extremidades inferiores en deportistas juveniles de proyección. Rev Bras Ciênc Esporte. 2018 Jul;40(3):295–301.
4. Bach AD, Stern-Straeter J, Beier JP, Bannasch H, Stark GB. Engineering of muscle tissue. Clin Plast Surg. 2003 Oct;30(4):589–99.
5. Menéndez JT, Pardo MR, Teruel FM, Juliá VL, Gil-Loyzaga P, Escriche EE. Fisiología Humana. 3rd ed. España: McGraw-Hill España; 2011.
6. Mahecha Matsudo SM. Poder del músculo esquelético en la salud y enfermedad. Rev Nutr Clínica y Metab. 2021;4(4):56–70.
7. Frontera WR, Ochala J. Skeletal Muscle: A brief review of structure and function. Calcif Tissue Int. 2015 Mar;96(3):183–95.

8. Durán-Osorno KM, Rebolledo-Cobos RC. Factores asociados a la fuerza prensil en adultos jóvenes aparentemente sanos. Duazary. 2025;22:e6337.

9. Martínez-Torres J, Gallo-Villedas JA, Aguirre-Acevedo DC. Características antropométricas y de composición corporal asociadas a la fuerza prensil manual en niños y adolescentes. Una Revisión Sistemática. Exploratoria. Andes Pediatr [Internet]. 2022 Dec 16;93(6):906–17. Available from: https://andespediatrica.cl.localhost/index.php/rchped/article/view/4408

10. Pérez Miguelsanz MJ. Distribución regional de la grasa corporal. Uso de técnicas de imagen como herramienta de diagnóstico nutricional. Nutr Hosp. 2010 Mar 1;(2):207–23.

11. Suchomel TJ, Nimphius S, Stone MH. The importance of muscular strength in athletic performance. Sport Med. 2016;46(10):1419–49.

12. Durán-Osorno KM, Rebolledo-Cobos RC. Factores asociados a la fuerza prensil en adultos jóvenes aparentemente sanos. Duazary. 2025 Mar 22;22:e6337.

13. García PLR. Fuerza, su clasificación y pruebas de valoración. 1997.

14. Ayllón FN, Alchapar JF. Determinación de los niveles de fuerza máxima aplicada, velocidad y potencia por medio de un test creciente en press de banca plano, en levantadores españoles. 2006.

15. Concha Y, Petermann F, Castro J, Parra S, Albala C, Van de Wyngard V, et al. Fuerza de prensión manual. Rev Med Chil. 2022;150(1075–1086):2–10.

16. Balsalobre-Fernández C, Varela-Olalla D. The validity and reliability of the my jump lab app for the measurement of vertical jump performance using artificial intelligence. Sensors. 2024;24(24).

17. Xu Z yang, Gao D fa, Xu K, Zhou Z qi, Guo Y kun. The Effect of Posture on Maximum Grip Strength Measurements. J Clin Densitom. 2021;24(4):638–44.

18. Morales J, Palacio D, Molina S. Correlación entre la potencia en miembros inferiores-superiores y el porcentaje de masa muscular en nadadores entre 13 a 15 años de la liga de natación de Antioquia. [Colombia, Medellín]: Universidad de San Buenaventura, Facultad de Educación; 2018.

19. Véliz C V, Cid FM, Rodríguez MJ. Relación de la fuerza, potencia y composición corporal con el rendimiento deportivo en nadadores jóvenes de la Región Metropolitana de Chile. 2020.

20. Hernández Martínez J, Cisterna DA. Potencia muscular en relación a la composición corporal en jugadores de voleibol adolescentes según género. Rev Ciencias la Act Física. 2022;23(1):1–8.

21. Benavides-Roca L, Salazar Orellana C, Díaz Coria G. Relación entre las características antropométricas de masa muscular de extremidad inferior y la potencia de salto de jóvenes deportistas. MHSalud Rev En Cienc Mov Hum Salud. 2021 Jul 1;18(2):1–16.

22. Anthony P, Morales R, Rocío M, Navarrete A, Jaime L, Morales C. Influencia de la masa grasa en el salto vertical de basquetbolistas de secundaria. 2017;36(1).

23. Akdogan E, Kanat EA, Simsek D, Cerrah AO, Bidil S, Bayram I. Relationship between body composition, multiple repeated sprint ability and vertical jump performance in elite badminton players. Int J Morphol. 2022 Jun;40(3):720–7.