Original article

Relationship between body composition and mechanical variables and strength performance in university athletes

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Summary

Objective: The purpose of this study is to determine the relationship between body composition and performance and mechanical strength variables in university athletes. The sample is composed of twenty-five university athletes who practiced team sports.
Material and method: Anthropometric variables of body weight, height and skinfolds were measured. Performance variables were obtained by measuring vertical jumps (SJ), countermovement jumps (CMJ) and the mid-thigh pull test, with which maximum isometric strength ("FIM") was obtained. In addition, power and mean propulsive velocity (MPV) were determined by performing 6 squats at 60% of each participant's body weight.
Results: The main results showed that the percentage of muscle mass did not present a significant relationship with power (R = -0.187; P = 0.371) and FIM (R = -0.155; P = 0.460). As for jumps, moderate significant relationships were observed for SJ (R = 0.534; P = 0.006), CMJ (R = 0.552; P = 0.007) and VMP (R = 0.545; P = 0.005). On the other hand, the percentage of fat mass did not present significant correlation with power (R = -0.109; P = 0.606) and FIM (R = -0.236; P = 0.255). On the contrary, MG obtained moderate significant correlations with SJ (R = -0.523; P = 0.007) and CMJ (R = -0.517; P = 0.008) and MPV (R = -0.509; P = 0.009).
Conclusions: There is a relationship between anthropometric variables of muscle mass and fat mass with jump height in SJ, CMJ and mechanical variables of strength such as MPV, it is suggested to deepen in new investigations that relate these variables.

Key words:
Body composition. Performance. Sports.

Relación entre la composición corporal con variables mecánicas y de rendimiento de fuerza en deportistas universitarios

Resumen

Objetivo: El objetivo de este estudio es determinar la relación entre la composición corporal con las variables de rendimiento y mecánicas de la fuerza en deportistas universitarios. La muestra está compuesta por veinticinco deportistas universitarios los cuales se desempañaban en deportes colectivos.
Material y método: Se midieron variables antropométricas de peso corporal, estatura y pliegues cutáneos. Por su parte, las variables de rendimiento fueron obtenidas con la medición de los saltos vertical (SJ), salto contra movimiento (CMJ), y prueba de tirón de medio muslo, con lo que se obtuvo la fuerza isométrica máxima (FIM). Junto con lo anterior, se determinó la potencia y la velocidad media propulsiva (VMP) con realización de 6 sentadillas al 60% del peso corporal de cada participante.
Resultados: Los principales resultados mostraron que el porcentaje de masa muscular no presentó relación significativa con la potencia (r = -0,187; p = 0,371) y la FIM (r = -0,155; p = 0,460). Con respecto los saltos, se pudo observar relaciones significativas moderadas para el SJ (r = 0,534; p = 0,006), CMJ (r = 0,552; p = 0,007) y la VMP (r = 0,545; p = 0,005). Por otra parte, el porcentaje de masa grasa no presentó correlación significativa con la potencia (r = -0,109; p = 0,606) y la FIM (r = -0,236; p = 0,255). A diferencia, la MG obtuvo correlaciones significativas moderadas con el SJ (r = -0,523; p = 0,007) y CMJ (r = -0,517; p = 0,008) y la VMP (r = -0,509; p = 0,009).
Conclusiones: Existe relación entre variables antropométricas de masa muscular y masa grasa con la altura de salto en SJ, CMJ y variables mecánicas de fuerza como la VMP, se sugiere profundizar en nuevas investigaciones que relacionen estas variables.

Palabras clave:
Composición corporal. Rendimiento. Deportes.

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Introduction

A human being's biological variables include his or her anthropometric characteristics and, therefore, provide relevant information about a subject's body composition. Consequently, it is possible to establish relationships between these characteristics and an individual's current physical performance and lifestyle[1]. Anthropometry is presented as a reliable, safe and low-cost tool to monitor body composition variables such as the percentage of subcutaneous fat and muscle mass in athletes compared with indirect methods[2,3]. Anthropometry is currently one of the assessments most used in the sports world as it helps define the morphological features of athletes and allows us to characterise different groups, determine nutritional status, monitor physical growth and contrast changes in somatotype, proportionality and body composition in the different stages of biological development[4-6].

It has been stated that the different phenotypes of athletes play a relevant role in performance, along with variables such as body weight, height, fat mass (FM), and muscle mass (MM)[7]. Specifically, it has been observed that there are positive correlations between MM and athletic performance in lower limb explosive strength tests such as squat jumping (SJ) and countermovement jumping (CMJ)[8], and between muscle volume and maximal squat strength[9]. It has also been postulated that muscle architecture characteristics, muscle thickness and fascicle angle and length can be used to predict sports performance[10].

Recently, with technological developments, it has been possible to obtain mechanical variables related to strength, such as mean propulsive velocity (MPV), maximal power and maximal isometric force (MIF), which are very useful for controlling fatigue and describing the neuromuscular performance of athletes[11-13]. In reference to these variables, positive correlations have been observed between the production of maximal force, power and jump height in CMJ[14].

Following on from this, the evidence shows that there are relationships between anthropometric characteristics and performance variables such as CMJ. However, to our knowledge, there is little information related to mechanical force variables which links speed of execution and maximal energy demand. Therefore, the objective of this study was to seek a relationship between body composition in terms of body fat and muscle mass, and mechanical and strength performance variables in university athletes.

Materials and method

This is an observational, quantitative-descriptive and cross-sectional study. All the participants voluntarily read and signed an informed consent form which falls within the ethical rules of the university and the Declaration of Helsinki.

We worked with a non-probability sample for reasons of convenience. The inclusion criteria were to be an athlete from the university's training programme and to be physically compatible with the assessments carried out, while the exclusion criteria were not to have completed all the assessments or to have an impediment to carry out the tests.

The sample consisted of 25 male university athletes from the Maule region, Chile.

Anthropometric assessment

For the anthropometric assessment, body weight was determined with Seca® digital scales (accuracy: 100 g) and height was measured with a Camry® digital height rod (accuracy: 25 to 200 mm). For the measurements of perimeter and diameters, an Avanturi calliper and segmometer was used, and the skinfolds were recorded with a Slim Guide adipometer (accuracy: 1 mm).

Body composition followed the protocols of the International Society for the Advancement of Kinathropometry (ISAK)[15], where the subject's head was placed in the Frankfurt plane and with as little clothing as possible to determine weight and height. The areas needed to obtain the perimeters (relaxed arm, uncorrected forearm, corrected thigh, corrected calf and corrected thorax), diameters (biacromial, bicrestal, humerus and femur) and skinfolds (triceps, subscapular, supraspinal, abdominal, front thigh, medial calf) were then marked. With these data and the formulas of Kerr (1988)[16], the MM and FM variables were obtained, both in kilograms and as percentages.

Squat jumping and countermovement jumping

For the jump tests, the Bosco[17] protocol was used and measurements were taken from the DM JUMP platform, processing the data with DM jump V2.2 Beta software. This instrument was validated in Chile by Saavedra and Vergara (2013). In the case of SJ, the protocol consisted of the individuals trying to make their centre of gravity rise as much as possible by performing a controlled hip, knee and ankle flexion-extension, maintaining 90º triple flexion of the lower limbs for 2 to 3 seconds and keeping them extended during the flight phase. 3 jumps were made, with a one-minute pause between each attempt. For the CMJ, the same protocol was used but without the 90º isometric pause.

Mean propulsive velocity and power

The MPV and power data were collected using a 1019 Hz linear position transducer (Chronojump-BoscoSystem, Spain). In the case of MPV, the data were expressed in $m \cdot s^{-1}$, and for power, the data were expressed in Watts (W). These variables were obtained by assessing six 90º squats at 60% body weight. The final result was obtained from the execution with the best value according to these variables..

Maximal isometric strength

MIF was assessed by means of the mid-thigh pull test. The instrument used was a strain gauge sampling at 80 Hz (Chronojump-BoscoSystem, Spain). The test consisted of each subject starting with his knees semi-flexed and the bar at mid-thigh height and then pulling as hard as possible[11].

Statistical analysis

The statistical analysis was conducted using SPSS 22 for Windows. The data were subjected to the Shapiro Wilk normality test. The descriptive statistics of mean and standard deviation were obtained for each variable. Pearson and Spearman correlations were conducted depending on the normality of each parameter, considering a 95% confidence interval. Based on the correlation coefficient (r-value), the relationships were interpreted as weak (0 to 0.39), moderate (0.4 to 0.69) and strong (0.7 to 1). A significance level of ≤0.05 was used for the analysis.

Results

Table 1 shows the characteristics of the university athletes based on body composition, performance variables and mechanical strength parameters. Body composition describes MM (%) (45.2 ± 4%) and FM (%) (11.7 ± 3.7%). The strength variables are shown as the SJ (33.9 ± 5.2 cm) and CMJ (37.2 ± 6.2 cm) heights. MPV (0.97 ± 0.14 m/s), power (1057.6 ± 359.1 W) and MIF (1432.1 ± 292.8 N) are also given.

The results indicate that MM (%) has significant correlations with SJ (r = 0.534; *P* = 0.006) and CMJ (r = 0.552; *P* = 0.007) (Figure 1). Moderately significant relationships were also obtained for MPV (r = 0.545; *P* = 0.005), as shown in Figure 2. However, no significant relationships were discovered with power (r = -0.187; *P* = 0.371) or MIF (r = -0.155; *P* = 0.460).

Figure 1 shows the correlations between MM (%) and SJ and CMJ height. In both cases, the correlations were significant (*P* >0.05).

Figure 2 shows the correlations between MM (%) and MPV (*P* <0.05).

All the significant correlations are given in Figures 1, 2, 3 and 4.

As for FM (%), no significant relationships were detected with power (r = -0.109; *P* = 0.606) or MIF (r = -0.236; *P* = 0.255). In contrast, moderately significant correlations between FM (%) and SJ height (r = -0.523; *P* = 0.007) and CMJ height (r = -0.517; *P* = 0.008) were observed

Table 1. Result of general characteristics, body composition and strength variables.

General data	Mean (±SD)
Age	19.5 (±1.69)
Weight (kg)	72.7 (±11.7)
Height (kg)	174.5 (±7.3)
Body Composition	
MM (%)	45.2 (±4)
FM (%)	11.7 (±3.7)
Strength variables	
SJ (cm)	33.9 (±5.2)
CMJ (cm)	37.2 (±6.2)
MPV ($m{\cdot}s^{-1}$)	0.97 (±0.14)
Power (W)	1057.6 (±359.1)
MIF (N)	1432.1 (±292.8)

kg: kilograms; cm: centimetres; MM: Muscle mass; FM: Fat mass; W: Watts; N: Newtons; SD: Standard deviation

Figure 1. Correlations between MM (%) and SJ and CMJ height. In both cases, the correlations were significant (*P* >0.05).

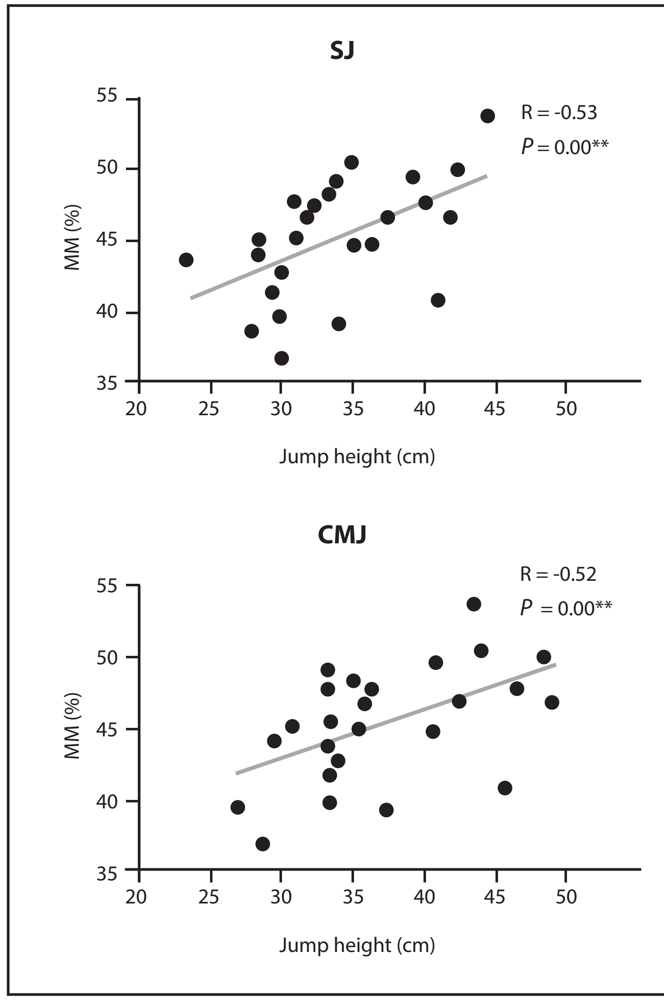
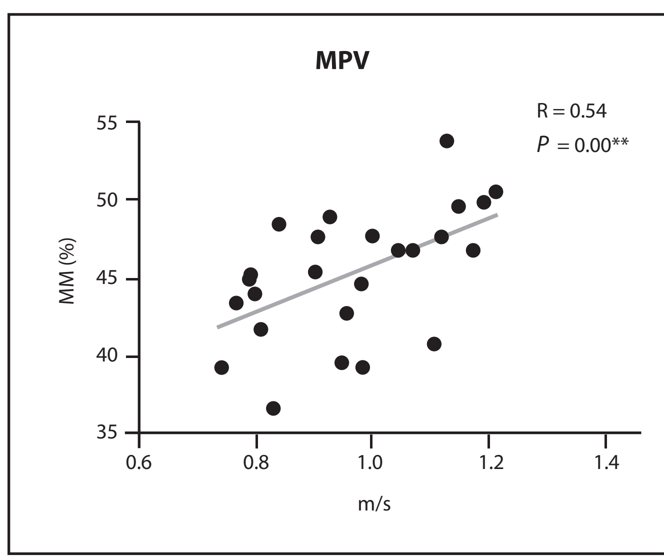


Figure 2. Correlation between MM (%) and MPV (*P* > 0.05).



(Figure 3). Finally, FM (%) showed moderately significant correlations with MPV (r = -0.509; P = 0.009) in the athletes assessed (Figure 4).

Figure 3 shows the correlations between FM (%) and SJ and CMJ height. In both cases, the correlations were significant (P >0.05).

Figure 4 shows the correlations between FM (%) and MPV (P <0.05).

Discussion

The purpose of this research was to show the relationship between body composition and strength variables in a group of university athletes. The main findings describe a relationship between both MM (%) and FM (%) and strength and performance variables such as SJ, CMJ, and MPV.

Figure 3. Correlations between FM (%) and SJ and CMJ height. In both cases, the correlations were significant (*P* >0.05).

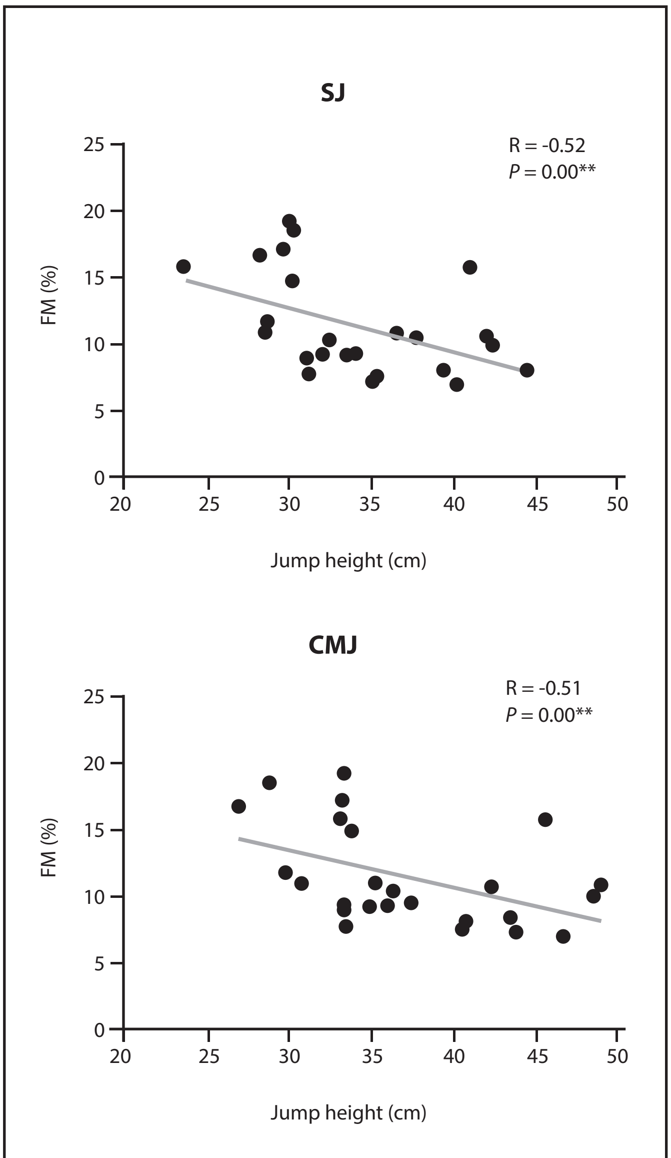
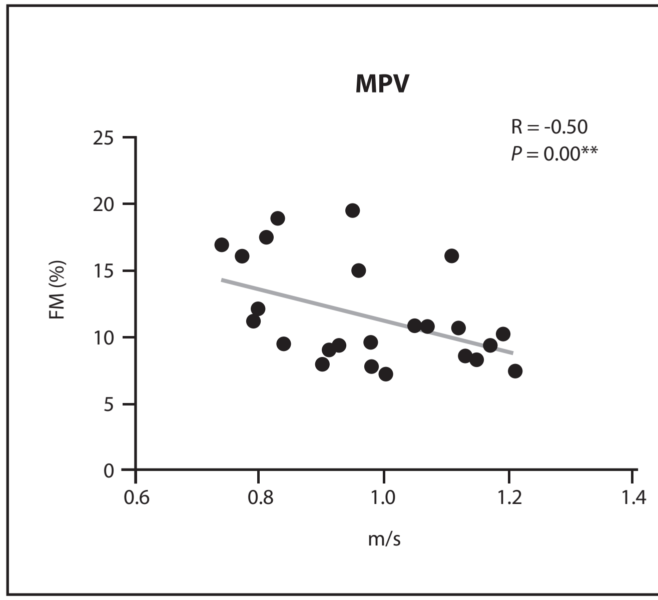


Figure 4. Correlation between FM (%) and MPV (*P*> 0.05).



Regarding the MM percentage, moderately significant relationships were observed in this study. Similar results have been reported by previous research[18,19]. Pérez-Contreras, *et al.*[18] reported similar data in under-15 footballers (CMJ: r = 0.58 and SJ: r = 0.51). Likewise, Ojeda-Aravena, *et al.*[19] found moderate relationships between muscle mass and SJ (r = 0.58) and CMJ (r = 0.58).

It has been observed that muscle development is related to better sports performance in rugby players[20]. These results can be explained because force production demands are influenced by the context in which the athlete operates, the actions of the sport requiring intense motor unit recruitment. Therefore, having greater muscle mass could be indicative of greater physical ability to meet these demands[21]. However, such claims are not absolute, the article by Bustos-Viviescas, *et al*[22] stating that muscle mass is not a reliable predictor for squat jumps. Within the MM data (%), a moderate relationship can be observed with MPV, which is relevant for determining and monitoring sports performance. MPV is found within velocity-based training (VBT) models, as expressed in the research by Liao, *et al.*[23], which confirms that VBT is effective in improving strength, jumping ability, linear sprints and changes in direction due to the development of neuromuscular components which favour skeletal muscle adaptations[23-25]. Fernández-Ortega, *et al.*[24] also found that training focusing on MPV produces an increase in lower limb muscle mass in football players. All this is in line with current evidence, which indicates that MPV is a reliable tool in sports training because it is possible to dictate specific velocities in order to recruit high-threshold motor units, which consequently favour different neural and structural adaptations of skeletal muscle[25-27].

Regarding FM (%), our research revealed moderate inverse correlations with SJ, CMJ and MPV performance. Research with different types of populations (university and professional athletes) reports similar findings to our study. In particular, Legg, *et al.*[29] found similar correlations (r = -0.61) between CMJ and FM (%) in university volleyball players[29]. Similarly, McDonald, *et al*.[28] found a strong inverse relationship (r = -0.82) between CMJ height and FM (%) in university athletes[30]. Alemdaroğlu[31] observed that the correlation between FM (%) and jump height was -0.487 in CMJ and -0.494 in SJ in professional athletes. These findings seem to indicate that the subjects of this study are not very far apart from higher level athletes in terms of FM (%).

The relationships observed agree with previous reports which state that a high % of FM may be a precursor to poor neuromuscular performance in sport[32].

Finally, it is important to note that, although our research highlights the relationship between both a lower percentage of FM and a higher percentage of MM and athletic performance, the existing literature has limited evidence on the MPV variable and its relationship with body composition. Therefore, one of the main limitations of this study is the small sample size and the use of doubly indirect measurement methods to assess body composition. However, its strengths include the use of valid and reliable technological tools to assess SJ, CMJ and MPV.

Conclusion

The data provided in this research show significant relationships between both a higher percentage of MM and a lower percentage of FM and mechanical and strength performance variables such as MPV and jumping ability in university athletes. It is important to point out that there is scant evidence linking MPV with body composition in university athletes. Therefore, it is recommended that future research look further into the influence of muscle mass and body fat on mechanical variables related to strength.

This area of study has significant potential to better understand the relationship between body composition and athletic performance in university athletes, which would allow training programmes to be optimised and results to be improved in this group of athletes.

Conflict of interest

The authors declare that they are not subject to any type of conflict of interest.

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