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Correlation Between Muscle Mass and Muscle Power in Youth Soccer Players

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Abstract

Objective: The aim of this study is to investigate the relationship between body composition, jump power, and jump height in order to identify potential strategies to enhance body composition, which may subsequently improve athletic performance in future professional soccer players.

Equipment and Methods: In this study, a total of 88 male subjects from the youth divisions of the Union Magdalena Football Club, comprising of 23 sub15, 24 sub17, and 44 sub20 players, were evaluated. Measurements were taken using bioelectrical impedance for weight anthropometry, precision stadiometer for height measurement, skinfold caliper and precision anthropometer for skinfold thickness and bone diameter measurements, respectively. Countermovement jump measurements were obtained using the Chrono Jump platform.

Results: In this study, a strong positive correlation was found between fat-free mass and jump power in the sub20 and sub17 categories ($r = 0.9$, $p < 0.01$ and $r = 0.86$, $p < 0.01$, respectively). However, this correlation was not observed in the sub15 category. Sub20 players showed a moderate negative correlation between muscle mass and jump power ($r = -0.399$, $p < 0.01$), while sub17 players demonstrated a moderate positive correlation between muscle percentage and jump height ($r = 0.419$, $p < 0.05$). In all categories, there was a high correlation between speed and jump height ($r = 0.90$, $p < 0.01$; $r = 0.99$, $p < 0.01$; and $r = 0.99$, $p < 0.01$ for sub20, sub17, and sub15, respectively).

Conclusion: These findings suggest that fat-free mass is an important predictor of lower limb power development, and that training programs targeting speed may be crucial in enhancing jump power and jump skills; likewise training jumping power can increase speed among youth soccer players.

Keywords: Muscle mass; Muscle power; Body composition; Athletic Performance; Young Soccer Players

Introduction

Football is a sport that involves a range of physical activities, including changes in direction, walking, jumping, running, sprinting, turning, and speed with accelerations and decelerations, all of which are characteristic of a sport with an intermittent profile. Given these demands, it is crucial to identify specific tests that assess athletes' physical abilities to design effective training programs based on their age, category, and performance level. Jumping ability tests, such as the squat jump (SJ) and countermovement jump (CMJ), are frequently used as measures of physical conditioning in elite athletes as they have been found to correlate with speed and strength parameters, such as 10, 20, and 50-meter sprints, and strength developed by elite athletes [1]. In fact, CMJ is a valid indicator of the stretch-shortening cycle, neuromuscular condition, and recovery, as its normal values return to baseline 48 hours after competition in elite athletes [2].

Vertical jump tests, including SJ, CMJ, and vertical jump, have been employed to evaluate the lower limb muscular power in football players. Muscular power is associated with maximum strength, which is linked with relative strength and strength skills developed on the field. Both jump tests and 30-meter sprint tests have been used to assess strength and power in this regard [3,4]. Jump tasks, such as SJ and CMJ, have been extensively studied as reliable tools for monitoring strength and power in sports such as football due to their simplicity and high applicability [5].Therefore, the assessment of strength and power of the lower limbs of young athletes in the youth divisions of football clubs using these tests holds significant potential to improve their physical abilities and develop effective training programs.

Certain studies have found notable variations in physical performance capacities and anthropometric variables across age categories and competition levels, emphasizing the significance of individualizing assessments and training profiles. This is particularly important as biological maturity status has a considerable influence on the size, adiposity, and specific functional capabilities and skills of young athletes in the sport [6]. In a systematic review article, higher values of maximal oxygen consumption (VO2max), muscular strength, muscular power (measured with vertical jump test), 10- and 30-meter sprint speed, agility, and lower body fat percentage were observed in elite football players as compared to amateur football players. Therefore, training programs need to be tailored to each position, level of play, and age [7].

A study conducted with elite football players aged 12 to 31 years reported that body fat has a slight inverse association with age during adolescence primarily attributed to the increase in lean body mass. The age of 17 years marked the inflection point where there is an amplified increase in lean body mass and a decrease in the rate of fat mass increase, with a more mesomorphic somatotype than ectomorphic or endomorphic [8]. The present study aims to establish possible relationships between different body composition components, particularly muscular percentage, and muscular power in players from different categories of the youth divisions of the Unión Magdalena Football Club.

Materials and Methods

Sample and Design

The present study aimed to evaluate all male subjects belonging to the youth divisions of Club Unión Magdalena, including U20, U17, and U15, thereby comprising a total global sample of 91 participants. All study subjects resided in Santa Marta and neighboring towns located within the Magdalena department of Colombia. Participants belonged to middle and lower-middle social strata and had engaged in sports practice for the past four years, with no acute musculoskeletal injuries or observed biomechanical alterations that affected normal ambulation or mobility. Prior to the assessments, a comprehensive medical history was obtained, which included acquiring informed consent and excluding those who met the exclusion criteria, such as having a known spinal pathology or a history of spinal surgery, active lower limb injury, abdominal surgery in the past six months, or ongoing low back pain. The consultation additionally inquired about injuries, pain, medication use, and diets. Subjects were further excluded from the study if they reported lower limb pain or displayed acute or chronic injuries of the lower limbs or spine. Following a detailed medical history, three athletes were excluded, leading to the inclusion of 88 participants from the youth division players of Club Unión Magdalena for further analysis in the present study.

This cross-sectional analytical study was performed using convenience sampling. In an initial consultation, anthropometric variables such as weight, height, and body mass index (BMI) were assessed, and skinfolds were measured by an expert professional using adipometry. Measurements of the wrist and elbow bone diameters were taken with an anthropometer, and fat, muscle, residual, and bone weights and percentages were determined using the Yuhasz formulas specifically designed for athletes. All anthropometric measurements followed the protocol of the International Society for the Advancement of Kinanthropometry (ISAK) [9].

To measure the countermovement jump (CMJ), a well-established protocol was followed, as described in the literature [10]. Participants stood in an upright position with hands on their waist and performed a vertical jump after a rapid countermovement downwards. During the knee and hip flexion action, the trunk was kept as upright as possible to prevent any possible influence of trunk extension on lower limb performance. In accordance with ethical standards for human experimentation outlined in the Declaration of Helsinki [11], all parents and/or legal guardians provided informed consent before minors were included in the study. The study was approved by a committee consisting of professionals from the youth divisions, which acted as an ethics committee, composed of a physiotherapist, sports physician, and technical coordinator.

Study Instruments

In this study, the anthropometric determination of weight utilized the in Body® Bioimpedance equipment, while the Seca® stadiometer was used for height measurement with precision. Skinfold measurements were taken using the Harpenden® skinfold caliper, bone diameter measurements were taken using the Harpenden® precision anthropometer, and the determination of countermovement jump power was conducted using the Chrono Jump platform, which is of Boscosystem® brand.

Statistical Analysis

In this study, all data are presented as mean and standard deviation, while the median and percentiles are also provided. Data analysis was conducted using IBM SPSS Statistics, version 21, from IBM Corp., based in NY, USA. Normality of the data was verified through the use of the Shapiro-Wilk test. Pearson's correlation analysis was used to assess the association or independence of variables, including percentage of muscle mass and fat-free weight with height, as well as jump power, if the distribution is considered "normal". When the distribution is not "normal", Spearman's rank correlation coefficient was utilized for this analysis. Upon statistical significance of <0.05, the null hypothesis (Ho) was rejected, and it was concluded that there is a significant difference between the correlation of the variables being examined.

Results

(Table 1) presents the descriptive statistics for age, anthropometric measurements, and countermovement jump

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variables within the U20, U17, and U15 categories. In (Table 2), the correlation between the variables was analyzed using the U20 category as a reference. A moderate negative correlation was observed between muscle mass and jump power, whereas no significant correlations were detected between % muscle and jump height, % fat and power, or % bone and jump height. Additionally, fat-free mass and jump power demonstrated a very high correlation when the significance level was $p < 0.01$. Furthermore, muscle power and velocity, as well as velocity and jump height, were found to be statistically significant with a significance value of $p < 0.01$, with the former correlation being moderate and the latter correlation being high.

Table 1: Descriptive statistics.

	U20	U17	U15
N	43	23	22
Mean age (years) and SD	18.8 ± 0.87	16.5 ± 0.66	14.7 ± 0.46
Mean weight (kilograms) and SD	68.6 ± 8.15	65.4 ± 6.58	54.6 ± 9.46
Mean height (meters) and SD	1.74 ± 0.073	1.73 ±0.05	1.65 ± 0.06
Mean % muscle and SD	50±1.9	48.1±3.96	47±3.18
Mean % bone and SD	16.9±0.99	17.5±1.02	19.4±2.4
Mean fat-free mass (kilograms)	62.5±6.6	58.6±6.25	49.3±8.09
Mean jump height (cm) (CMJ)	37.7±3.5	35.7±5.09	29.2±6.24
Mean jump power (watts) (CMJ)	917±122	847±117	654±131
Mean jump velocity (m/s) (CMJ)	2.71±0.13	2.64±0.18	2.38±0.26

N: Sample; %: percentage; fat-free mass: (FFM); CMJ: Countermovement jump test; m/s: meters/seconds; cm: centimeters; w: watts; U20: under 20 category; U17: under 17 category; U15: under 15 category

Table 2: Statistically significant correlation values for body composition and variables of jump height, power, and velocity in CMJ.

Categories	Variables	Counter Movement Jump	
		High (cm)	Power (w)
U20	% Muscular	0,11	-0,399**
	% Bone	-0,24	-0,27
	FFW	0,21	0,925**
	Speed (CMJ) (m/s)	0,908**	0,430**
U17	% Muscular	0,419*	0,11
	% Bone	-0,3	.0,38
	FFW	0,31	0,863**
	Speed (CMJ) (m/s)	0,994**	0,718**
U15	% Muscular	0,04	-0,17
	% Bone	0,25	.0,24
	FFW	-0,21	0,4
	Speed (CMJ) (m/s)	0,997**	0,632**

%: percentage; FFW: Fat-Free Mass; CMJ: Counter Movement Jump test; m/s: meters/second; cm: centimeters; w: watts; U20: under 20 category; U17: under 17 category; U15: under 15 category; *P<0.05; **P<0.01.

For the U17 category, there was a moderate correlation between % muscle and jump height, and a high correlation was observed between fat-free mass and jump power at a significance level of $p < 0.01$. Moreover, the correlations between muscle power and velocity, and velocity and jump height, demonstrated statistical significance with a significance value of $p < 0.01$, but the former correlation was high, while the latter correlation was very high. No significant correlations were observed for the other variables of this category. In the U15 category, muscle power and velocity, as well as velocity and jump height, showed statistical significance with a significance value of $p < 0.01$. The correlation between the former was moderate, while that between the latter was very high. None of the other variables showed significant correlations within this category, thus, the null hypothesis could not be rejected.

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Discussion

The findings of this study indicate a significant correlation between fat-free weight and lower limb muscle power within the U17 and U20 categories. Conversely, no such correlation was observed in the U15 category. This lack of significance in the younger group may be related to the ongoing period of high growth in body weight and height, indicating neuromotor and musculoskeletal immaturity. Additionally, as young elite athletes age, their fat-free weight increases, resulting in a higher muscle and bone mass and a more mesomorphic somatotype [8]. Furthermore, greater biological maturity implies a greater increase in neuromotor development indicators, such as muscle power [12], which affects the muscle/bone relationship more in individuals aged 20 or older than in those aged 15.

For the U17 and U20 categories - where musculoskeletal development is approaching full maturity - fat-free weight is strongly correlated with muscle power. However, no correlation was observed between muscle and bone percentages and jump height or jump power. This suggests that the relationship between isolated muscular and bone components is not a determinant in the development of jump power, but rather the appropriate relationship between them. Importantly, this study's key finding was the strong correlation observed between jump power, jump height, and the speed developed during the countermovement test, indicating these determinative skills in soccer development are highly dependent on the speed with which they are performed. As such, it is strongly suggested that the emphasis should be placed on training speed, rather than programs that aim to increase muscle mass, to effectively develop these skills.

One limitation to the results of this study is the use of subcutaneous adipometry and anthropometry utilizing Yuhasz formulas to determine anthropometric values in the athletes. Future studies are recommended to utilize more reliable and precise technology such as 3D scanning or Magnetic Resonance Imaging, among others, which are considered the "gold standard" in body composition measurements. Additionally, it is important to conduct measurements in different sports clubs to include more athletes, including those from diverse regions and age categories, to determine the generalizability of the results to other scenarios.

Conclusion

The findings of the present study demonstrate a clear and robust relationship between fat-free weight and lower limb jumping power (indirectly reflecting lower extremity muscle power) in players from the U17 and U20 divisions of the Unión Magdalena soccer team. However, the study reveals no significant correlation between muscle percentage and jump power. Based on these results, it is suggested that the development of jump power is more reliant on total fat-free mass, which comprises both muscle and bone tissue, than on isolated muscle or bone mass.

Additionally, these results underscore the importance of speed in training programs designed to improve jump power and jump height skills; likewise training jumping power can increase speed in youth soccer players. Specifically, the implementation of such programs must involve a focus on increasing speeds to optimize results in these variables.

Conflict of Interest

The authors declare no competing interest.

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