Validation of a Novel Equation to Predict Lower-Limb Muscle Mass in Young Soccer Players: A Brief Communication

Validación de una Nueva Ecuación para Predecir la Masa Muscular de los Miembros Inferiores en Jugadores Jóvenes de Fútbol: Una Comunicación Breve

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SUMMARY: Lower-limbs appendicular muscle mass is a key body composition trait related to health and performance. Considering the relevance of lower-limbs appendicular muscle mass in soccer players, the assessment and monitoring of this variable with a low-cost tool would be of great value in order to improve performance through training and nutritional interventions. This study aimed to develop a multiple regression model in order to validate, through dual-energy X-ray absorptiometry, a novel equation to predict lower-limbs appendicular muscle mass in young soccer players using anthropometric variables. Forty-two soccer players of the Chilean National Team (age, 17.1±1.3 years; body mass, 70.0±6.8 kg; height, 175.0±6.6 cm) underwent anthropometrically and body composition assessments. Forward stepwise linear regression was used to develop the equation to estimate the lower-limb appendicular muscle mass. The estimated results were compared with measurements by dual-energy X-ray absorptiometry. The best predictor model to estimate lower-limbs appendicular muscle mass was (kg): (-21.268 + (0.087*height) – (0.853*middle thigh circumference) – (0.329*middle thigh skinfold) + (1.136*corrected middle thigh circumference) + (0.306*calf circumference)) (R2= 0.83). The lower-limbs appendicular muscle mass estimated by the equation and measured by DXA were similar (14.71±1.72 kg vs 14.76±1.89 kg, respectively), and have a good concordance according to Bland-Altman method (mean difference: 0.049 kg; 95 % IC: -1.481 to 1.578 kg) and Lin's concordance correlation coefficient (0.91; 95 % CI: 0.85 – 0.96) methods. In conclusion, the predictive equation is a valid, easy to calculate, and a low-cost tool to predict lower-limbs appendicular muscle mass in young soccer players.

KEY WORDS: Anthropometry; Muscle mass; Lower limb; Soccer players.

INTRODUCTION

Lower-limbs appendicular muscle mass (aMM) is a key body composition trait. Regardless from its importance on health-related markers (Kim *et al*., 2014), aMM is also a key marker of physical performance in sport-related contexts such as soccer (Wong *et al*., 2009). Particularly in young soccer players, is related with explosive physical fitness, competitive level and long-term success (Reilly *et al*., 2000; Chena Sinovas *et al*., 2015). Therefore, the regular assessment and monitoring of aMM among young soccer players should be incorporated into their regular evaluation schedules.

Indirect methods, such as somatotype profiling (Heath & Carter, 1967) have been implemented to assess body composition in soccer players (Henríquez-Olguín *et al*., 2013). However, the somatotype does not allow a detailed depiction of different body composition components. Biological assumptions (i.e., a constant density of a given type of tissue among humans) are routinely used to assess body composition. Nevertheless, the density and the relative mass of different tissues is not constant among humans (Martin *et al*., 2003). A popular indirect method was developed nearly 30 years ago, in order to asses body composition divided into five components (i.e., tissue mass; bone mass; muscle mass; fat mass; residual mass), for an estimation of both absolute and relative body composition values. This method demonstrated a high correlation between total and fragmented mass (r=0.97) using 21 anthropometric variables, with high reliability (Kerr, 1988). Unfortunately, the method mentioned above does not allow an adequate prediction of aMM.

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An alternative approach to assess body composition, with particular reference to aMM, is the gold standard dual-energy X-ray absorptiometry (DXA) (Chan, 1992; Milsom *et al.*, 2015). Measurements with DXA have been used as a gold standard to validate other methods and to quantify aMM through multiple regression equations, using anthropometric variables (Rodríguez *et al.*, 2012). However, the validation of such equations has not been corroborated in young soccer players.

Therefore, this study aimed to develop a multiple regression model (MRM) validated through DXA in order to provide an equation to predict aMM in young soccer players using anthropometric variables. Such information would be of great value to practitioners working with young soccer players, allowing them to assess and monitor aMM with simple and inexpensive equipment. Considering the relevance of aMM in young soccer players for both health and soccer performance, the results arising from this study would be essential to further advance the field of knowledge regarding body composition in this population.

MATERIAL AND METHOD

Subjects. Soccer players (n=42; age, 17.1±1.3 years; body mass, 70.0±6.8 kg; height, 175.0±6.6 cm) from the Under 20 National Team participated in this study. Table I shows their physical characteristics.

Standardized measurements were obtained in two days, always between 9:00 and 13:00 h, under adequate hydration state, at least 2-3 hours after their last meal, and ≥48 hours after their last training or competition session. This study was conducted by following the Declaration of Helsinki and approved by the ethics committee of the responsible Institutional Department.

Anthropometric Measurements. Anthropometric measurements were obtained according to the International Society for the Advancement of Kinanthropometry (ISAK) (Stewart *et al.*, 2011). The measurements were completed by the same ISAK II level certified evaluator. Skinfolds, perimeters, and diameters were measured with the Rosscraft

SRL® kit. Twenty-one anthropometric variables were used to calculate tissue mass, bone mass, muscle mass, fat mass, and residual mass, following previous methods (Kerr). Besides, the flexed-arm perimeter was used to calculate the somatype.

Body mass was measured with a manual scale (SECA, Vogel & Halke GmbH, Hamburg, Germany; precision of 0.1 kg), and height was measured with a stadiometer incorporated in the scale (SECA, Vogel & Halke GmbH, Hamburg, Germany; precision of 0.1 cm), while the participants were instructed to take and hold a full breath.

DXA Measurements. Using a full-body DXA scanner (Lunar Prodigy Advance®, GE Medical Systems Lunar, Madison, WI, USA), an experienced technician ensured the proper positioning of the participants, according to the manufacturer's guidelines. Subjects laid flat on the scanner, with light clothes, and without any metal objects. A whole-body scan of 20 minutes was used. The same experienced technician analyzed the results in order to measure fat, mineral, and lean mass, using the manufacturer's software. The appendicular muscle mass was obtained using a simple equation (Rodríguez *et al.*, 2012). Equation 1: aMM = (FM + BM) - FFM. Were aMM = appendicular muscle mass; FM = fat mass; BM = bone mass (wet bone); FFM = free fat mass.

However, as DXA measure dry bone, another equation was used to calculate wet bone (Heymsfield *et al.*, 1990). Equation 2: WBM = DBM / 0.55 x 1.82. Were WBM = wet bone mass; DBM = dry bone mass.

Statistical analysis. DXA and anthropometric data were analyzed by a forward stepwise linear regression to determine the best prediction model for aMM. The assumptions of normality of the distribution error, collinearity and homoscedasticity were confirmed through Shapiro-Wilk, variance inflation factor, and Breusch-Pagan/Cook-Weisberg test, respectively. Bland-Altman analysis and Lin's concordance correlation coefficient were used to test the agreement between aMM by the MRM and DXA. Differences between aMM predicted by the MRM and DXA were evaluated using a paired-parent student's t-test ($P<0.05$). Statistical analysis was performed using STATA 13.0 (StataCorp, College Station, Texas, USA).

Table I. Basic characteristics of soccer players (n=42).

	Mean±SD	Maximum	Minimum
Age (years)	17.0±1.3	19.0	16.0
Body mass (kg)	70.0±6.8	86.0	58.0
Height (cm)	175±6.6	187.0	160.0
Body mass index (kg.m^{-2})	22.9±1.4	26.3	19.9

RESULTS

The predictive equation obtained explain ~85 % of the total variability of the lower-limbs appendicular muscle mass (R^2= 0.83). As is shown in Figure 1, there were no differences (p=0.687) in lower-limbs appendicular muscle mass obtained by DXA (14.76±1.89 kg) and estimated by the predictive equation (14.71±1.72 kg). The mean of differences was -0.04881 (95 % IC: -0.2923 to 0.1947).
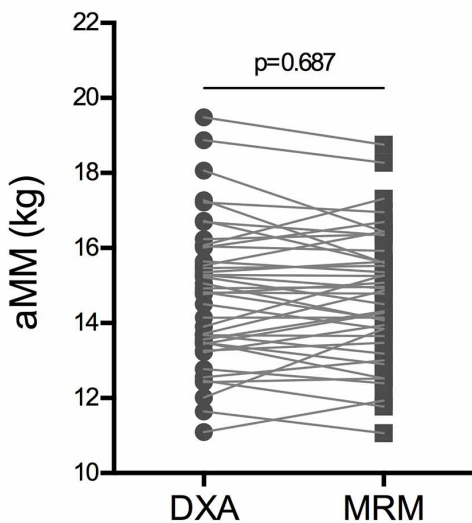

Fig. 1. Lower-limbs appendicular muscle mass (sMM) measured by dual-energy X-ray absorptiometry (DXA) and estimated through a multiple regression model (MRM).
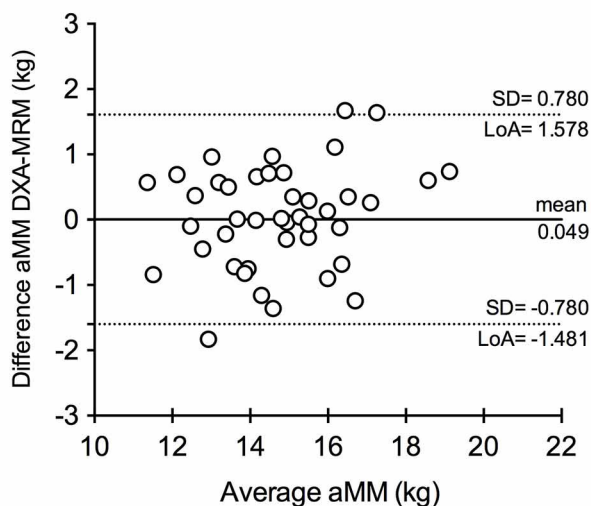

Fig. 2. Bland–Altman concordance for lower-limbs appendicular muscle mass (aMM) measured by dual-energy X-ray absorptiometry (DXA) and estimated with a multiple regression model (MRM) in young male soccer players (n=42). SD: standard deviation. LoA: limits of agreement.

Figure 2 shows the relation between the mean values of lower-limbs appendicular muscle mass measured by DXA and the estimated by the predictive equation (Bland–Altman method), showing a good concordance (mean difference: 0.049 kg; 95 % IC: -1.481 to 1.578 kg).

A Scatter plot diagram with a line of identity for Lin's concordance correlation between values of lower-limbs appendicular muscle mass measured by DXA and the estimated by the predictive equation is depicted in Figure 3. The results showed a good concordance between both measurements (Lin' concordance correlation coefficient: 0.91; 95 %IC: 0.85–0.96).
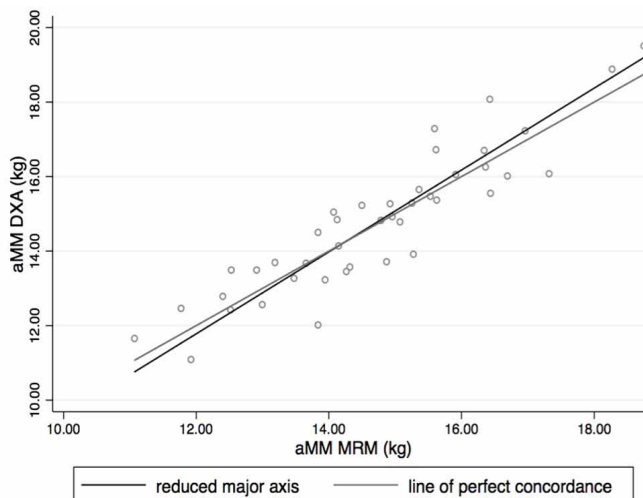

Fig. 3. Lin's concordance correlation coefficient between lower-limbs appendicular muscle mass (aMM) measured by dual-energy X-ray absorptiometry (DXA) and estimated with a multiple regression model (MRM) in young male soccer players (n=42). The grey line represents the line of perfect concordance.

DISCUSSION

In this study, we developed an equation to predict lower-limbs appendicular muscle mass in young soccer players. The predictive equation, which had a high degree of agreement with the method used for comparison (DXA), was obtained by a multiple linear regression model that includes the anthropometric variables height, middle thigh circumference, middle thigh skinfold, corrected middle thigh circumference, and calf circumference. Considering the relevance of lower-limbs appendicular muscle mass in soccer players for both health and soccer performance, the predictive equation of aMM could allow the assessment and monitoring of this variable with simple and inexpensive equipment.

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Also, as differences between whole body and aMM change during a soccer season (Milsom *et al*., 2014), current results offer the possibility to discriminate such differences for a better nutritional and training planning. Anthropometric variables such as height, body mass, chronological age, sitting height, and leg length, have been considered by other researchers in order to improve the analysis of the body composition of young participants according to maturity status (Malina *et al*., 2005). However, in the current study maturity status was not considered, as all participants were at an aging stage were maturation is usually at their peak (i.e., Tanner scale 5) (Moran *et al*., 2017). Nevertheless, future studies are needed in order to elucidate an equation for young soccer players with different maturation status, for both male and females, as the maturation process differ according to the sex of athletes (Malina *et al*., 2004).

Moreover, considering the potential relationship between body composition, maturation status, and stress hormone levels in response to training in young soccer players (Handziska *et al*., 2015), more research in relation to the potential role of aMM would be valuable, to influence the hormonal profiling and thus to control the training load during the soccer season in athletes with different maturation. The whole-body composition has been related to team success over an entire season (Arnason *et al*., 2004). In young male soccer players, body composition may affect physical fitness, such as maximal oxygen consumption, submaximal running cost, intermittent endurance running, acceleration and maximal velocity sprinting, change-of-direction ability, jumping, slow and fast stretch-shorting cycle muscle performance, maximum kicking speed, and dribbling ability (Wong *et al*.), critical traits of soccer-team success (Arnason *et al*.). However, such a relationship may vary according to the player´s position on the field, at least in young teams (Wong *et al*.). Future studies should aim to replicate the current study increasing the sample size, to compare values according to player's position, and to consider if aMM may offer a more powerful predictor of team success at long-term.

In summary, the equation obtained:

aMM (kg) = [-21.268 + (0.087*height) – (0.853*middle thigh circumference) – (0.329*middle thigh skinfold) + (1.136*corrected middle thigh circumference) + (0.306*calf circumference)]

Is a valid, easy to calculate, and low-cost tool to predict lower-limbs appendicular muscle mass in young soccer players. Its application will allow us to calculate the lower-limbs appendicular muscle mass for its use in young soccer players in order to improve performance through monitoring training and nutritional interventions.

ZAPATA-GÓMEZ, D.; CERDA-KOHLER, H.; BURGOS, C.; BÁEZ-SAN MARTIN, E. & RAMIREZ-CAMPILLO, R. Validación de una nueva ecuación para predecir la masa muscular de los miembros inferiores en jugadores jóvenes de fútbol: Una comunicación breve. *Int. J. Morphol., 38(3)*:665-669, 2020.

RESUMEN: La masa muscular de los miembros inferiores es un factor antropométrico clave relacionado a la salud y el rendimiento deportivo. Considerando la relevancia de este factor en jugadores de fútbol, la medición y monitoreo de esta variable a través de herramientas prácticas de bajo costo puede ser de gran utilidad para lograr objetivos relacionados a mejorar el rendimiento a través del entrenamiento e intervenciones nutricionales. El objetivo de este estudio fue desarrollar un modelo de regresión lineal con el objetivo de validar una nueva ecuación predictiva de la masa muscular de miembros inferiores en jugadores jóvenes de fútbol. Cuarenta y dos jugadores jóvenes de fútbol pertenecientes a la Selección Nacional Chilena (17,1±1,3 años; 70,0±6,8 kg; 175,0±6,6 cm) fueron sometidos a evaluaciones antropométricas y de composición corporal. La regresión lineal de pasos hacia adelante fue utilizada para desarrollar la ecuación para estimar la masa muscular de miembros inferiores. Los resultados estimados fueron comparados con medición de absorciometría de rayos X de doble energía (DEXA). El mejor modelo predictor de masa muscular de miembros inferiores (kg) fue: (-21,268 + (0,087*talla) – (0,853*circunferencia de muslo medio) – (0,329*pliegue de muslo medio) + (1,136*circunferencia de muslo medio corregida) + (0,306*circunferencia de pantorrilla)) (R^2= 0,83). La masa muscular estimada por la ecuación y la medida por DEXA fue similar (14,71±1,72 kg vs 14,76±1,89 kg, respectivamente), y tuvo una buena concordancia acorde al método Bland-Altman (diferencia promedio: 0,049 kg; 95 % IC: -1,481 to 1,578 kg) y el coeficiente de correlación de concordancia de Lin (0,91; 95 % CI: 0,85 – 0,96). En conclusión, la ecuación predictiva desarrollada en este estudio es una herramienta válida, fácil de calcular y de bajo costo que permite estimar la masa muscular de miembros inferiores en futbolistas jóvenes.

PALABRAS CLAVE: Antropometría; Masa muscular; Miembros inferiores; Futbolistas jóvenes.

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