ANTHROPOMETRIC MODELS TO PREDICT BODY SEGMENTED MASS COMPARED WITH DXA IN PROFESSIONAL FOOTBALL SOCCER PLAYERS

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ABSTRACT:

PURPOSE: To compare anthropometric models to predict head, thorax, inferior limbs and superior limbs segmented mass (SM) in professional soccer players using DXA as the reference method.

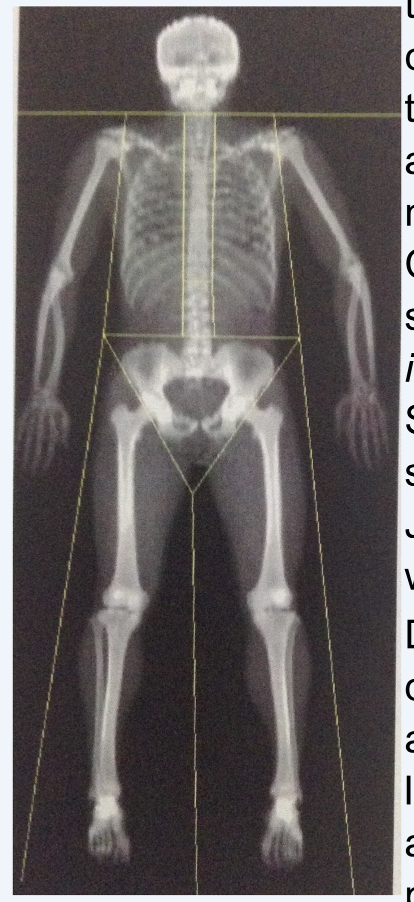
METHODS: 85 male professional football soccer players aged 19.9 ± 4.7 years old were evaluated. Body weight, 10 skinfolds, 14 circumferences, 6 segments, 3 heights and 9 diameters were measured. DXA whole body scan was performed with a Hologic QDR equipment. The DXA measurements were established as references to compare the anthropometric equations to predict SM. An ANOVA test was used with Dunnett´s test as *post hoc*, to find differences between each SM equation and total estimated body weight (SM sum) with DXA.

RESULTS: None of the equations had differences when comparing total estimated body weight with the measured one with DXA, but none of the equations could predict accurately all the SM´s. All equations fail to estimate head mass. The Marfell-Jones' and McConville's equations show no differences at the thorax SM, while Barter's equation had no differences in the SM superior limbs and Clauster in the SM inferior limbs.

CONCLUSIONS: Using only one author´s model could lead to errors in the prediction of SM even if the sum of them had no differences against the measured body weight. A combination of the most accurate authors equations should be used rather than only one author´s model. Although other mathematical models have been developed, their anthropometric measurements are not of common use. The development of new SM models should be encouraged to facilitate the study of the SM in athletes.

INTRODUCTION

Prediction of segmented mass (SM) has biomechanical and body composition applications (Drillis, 1964). Several models have been developed to predict it (Drillis, 1964; Marfell-Jones, 1984). These models estimate the whole body mass in different detailed segments (arms, forearms, hands, thighs, calves, head, thorax) or in more simple segments (superior limbs, inferior limbs, head, thorax). They could be calculated as a percentage of body weight, or using another anthropometric measurements to predict it (Marfell-Jones, 1984). The majority of these models have been validated in older-cadaver samples (Barter, 1957, Clauster, 1969; Chandler, 1975). Few have been done *in vivo* in adults (McConville, 1980), in a wider age spectrum and in athletic populations (Marfell-Jones, 1984). Some SM equations used valid *in vivo* validation methods for the predicted SM (Drillis, 1964), but others try to validate the SM equations making a comparison between measured and estimated body weight (SM sum) and this does not necessarily mean an accurate estimation of each SM (Marfell-Jones, 1984). Therefore there is a need to test these equations in the athletic population with a more accurate method.



Dual X-ray absorptiometry (DXA) can estimate body mass accurately, around 1% difference compared with a body scale body weight (Prior, 1997). Also it can estimate accurately the mass of the segments in four sections (head, trunk, superior limbs, inferior limbs) (Andreoli, 2009). Therefore, the purpose of this study was to compare anthropometric models to predict segmented mass (SM) in professional football soccer players using DXA as the reference method.

METHODS

Eighty five male professional football soccer players (aged 19.9 ± 4.7 years old) were evaluated. Subjects attended our laboratory in the morning after an overnight fasting. To calculate SM through equations several anthropometric measurements were evaluated: body weight (Tanita, TBF410), 10 skinfolds (Harpenden), 14 circumferences (Lufkin,W606ME), 6 segments (Rosscraft), 3 heights (Rosscraft) and 9 diameters (Rosscraft) were measured following the ISAK protocol (Stewart, 2011). DXA whole body scanning was performed with a Hologic QDR fan beam equipment. The segments obtained with DXA measurements (Head, Thorax, Superior limbs, Inferior limbs) were established as references to compare the anthropometric equations to predict SM. Those anthropometric models which segments were not similar to the DXA ones were adjusted (e.g. sum of hand, forearm and arm for one superior limb). As the anthropometric measurements were done in only one side of the subjects, the estimated mass of that limb was multiplied by two. An ANOVA test was used, with Dunnett´s test as *post hoc*, to find differences between each SM equation and total estimated body weight (sum of all SM of each model) compared with DXA. The statistical significance was set as $p<0.05$.

RESULTS

None of the equations had differences in estimated body weight compared with DXA total mass or with the measured in a body-scale (Figure 1).

All equations failed to estimate head mass. The best equations to predict SM of thorax mass were McConville's and Marfell-Jones' equations, this was also true when head and thorax were estimated together. SM of superior limbs were better estimated with Barter's equation. Clauster's equation was the one that better estimated inferior limbs mass. Chandler's equations failed to estimate all segments (Figure 1). However the sum of the SM estimated by the McConville or Marfell-Jones for the head and thorax SM, the Barter equation for superior limbs and the Clauster equation for inferior limbs gives a similar result for total mass as the one measured by DXA. Net differences (and differences expressed as percentage) between SM estimation and DXA for each author and segment are shown in Table 1.

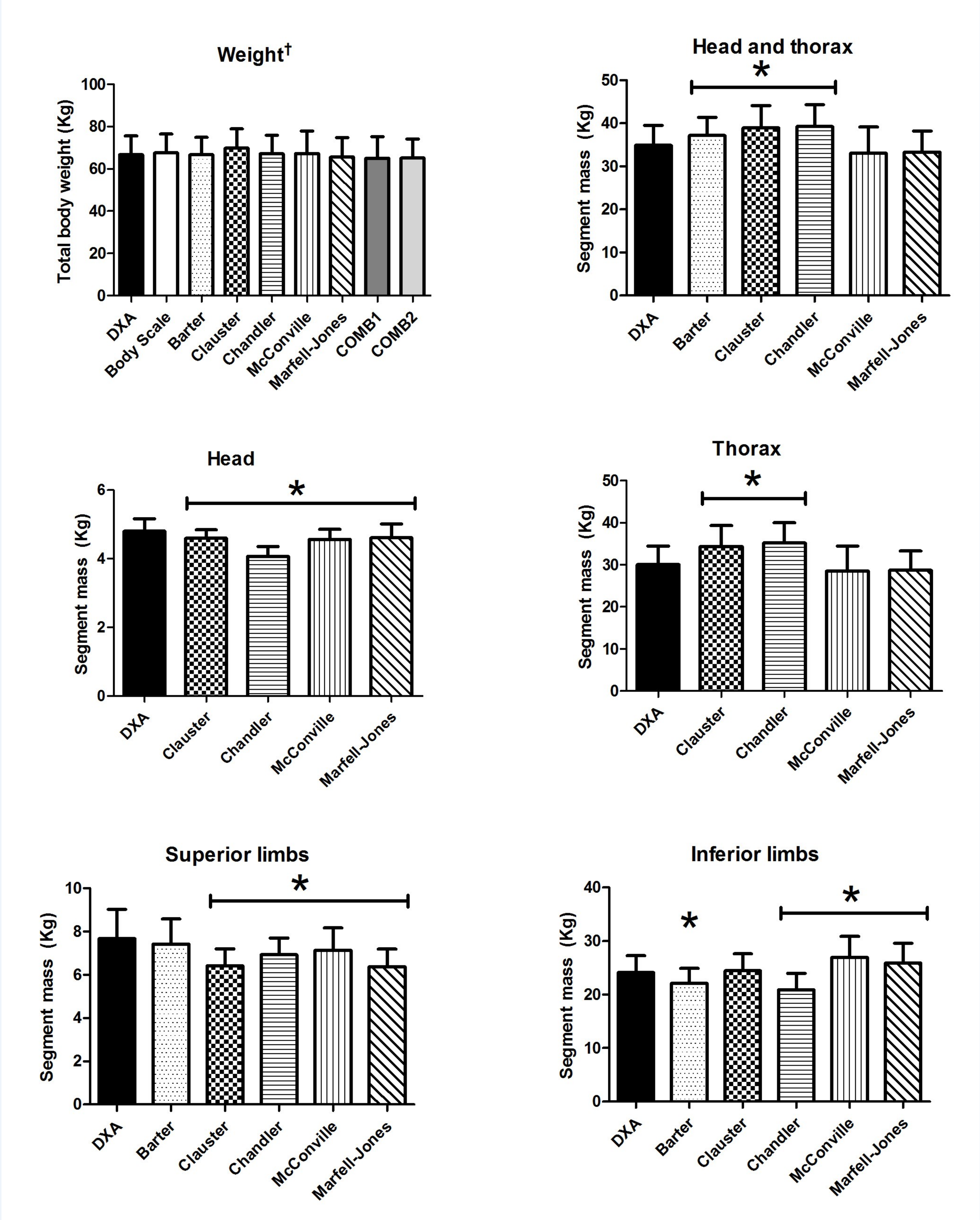


Figure 1. Comparison per region between several SM equations and DXA. When head and thorax are analyzed independently Barter's equations were not included because these two segments are calculated together in this author's model.

COMB1: Combined body weight with McConville, Barter and Clauster equations; *COMB2:* Combined body weight with Marfell-Jones, Barter and Clauster equations. Author's equations are listed for head-thorax, superior limbs and inferior limbs respectively.

† Body weight without significant differences compared with DXA.

*Significant difference (p<0.05) compared with DXA.

CONCLUSIONS

Comparing different models we found that using just one author's model can result in prediction errors of SM, even if the sum of them had no differences contrasted with the measured body weight or DXA's body weight. The sum of the estimated SM body weight (SM sum) compared with actual body weight should not be used as the validation method.

In this study we found that the best equations to predict SM in professional soccer players were: McConville and Marfell-Jones for head-thorax, Barter for superior limbs and Clauster for inferior limbs. Also we show that the sum of these SM equations could be used to predict total body mass.

Although other mathematical models of SM have been developed, their anthropometric measurements are not of common use and therefore were not included. The development of new SM models using accurate SM reference methods should be encouraged to facilitate the study of the SM in athletes.

Table 1. Comparison of differences between each author equation and DXA segment mass.

			Author				
			Barter (1957)†	**Clauster (1969)**	**Chandler (1975)**	**McConville (1980)‡**	**Marfell-Jones (1984)**
Segment	Head	Kg	2.30 ± 0.92*	-0.21 ± 0.24*	-0.73 ± 0.28*	0.24 ± 0.27*	-0.19 ± 0.33*
		%	6.88 ± 3.14	-4.04 ± 4.82	-15.09 ± 5.17	4.84 ± 5.49	-3.92 ± 6.62
	Thorax	Kg		4.28 ± 1.05*	5.13 ± 0.96*	1.55 ± 2.06	-1.39 ± 2.01
		%		14.31 ± 3.03	17.27 ± 3.18	5.89 ± 7.14	-4.63 ± 6.85
	Superior limbs	Kg	0.21 ± 0.44	-1.26 ± 0.69*	-0.75 ± 0.66*	0.54 ± 0.43*	-1.31 ± 0.63*
		%	3.28 ± 6.32	-15.49 ± 6.54	-8.63 ± 7.31	6.41 ± 4.54	-16.24 ± 5.74
	Inferior limbs	Kg	-1.96 ± 0.98*	0.35 ± 0.80	-3.22 ± 0.94*	-2.87 ± 1.17*	1.79 ± 1.14*
		%	-7.97 ± 3.56	1.54 ± 3.30	-13.45 ± 3.82	-11.78 ± 4.35	7.38 ± 4.49
	Total weight	**Kg**	**-0.77 ± 0.81**	**2.32 ± 0.73**	**-0.41 ± 0.05**	**1.58 ± 1.68**	**1.95 ± 2.15**
		%	**-1.00 ± 1.06**	**3.49 ± 1.13**	**-0.62 ± 0.002**	**2.61 ± 2.76**	**2.94 ± 3.30**

All values are mean ± standard deviation.

*Significant differences (p<0.05) compared with DXA.

†Barter's model estimates head and thorax together.

‡McConville's model converted with Chandler's model.

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