Original Article

Comparison between two equations for the estimation of weight and height in Peruvian adult patients

Comparação entre duas equações para estimar de peso e altura em pacientes adultos peruanos

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ABSTRACT

Introduction: Weight and height are necessary and essential measurements for the identification and treatment of patients with malnutrition or nutritional risk. However, there are clinical situations that prevent these measurements from being taken. The equations proposed for estimation have been established and validated in other countries. The present study aims to determine the most appropriate equation for Peruvian adult patients. **Methods:** Comparative, observational, prospective and cross-sectional study, which included adult patients of the medicine unit of the Hospital General Jaén. The anthropometric measurements collected were selected according to the Chumlea and Rabito equations. Bland Altman analysis and Intraclass Correlation Coefficient (ICC) were used to evaluate the concordance. The quality of the estimation was evaluated by the Root Mean Square Error (RMSE) and the Mean Relative Error (ERM) methods. Statistical significance was considered at a value of $p<0.05$. **Results:** A total of 41 patients were included, with a mean age of 34.49 ± 12.55 years. Out of all patients, 63.41% were women. The mean weight was 63,65 ± 10.29 kg, and for height 158.70 ± 8.45 cm. The Rabito equation presented closer limits of agreement (-7.06 to 6.83 cm), better concordance (ICC=0.908) and better quality adjustment (RMSE=3.501; ERM=2.231) with the real height, when compared to the Chumlea equation. In relation to the estimated weight, the Rabito equation obtained closer limits of agreement (-7.33 to 10.84 kg), better agreement (ICC=0.882) and better quality adjustment (RMSE=4.902; ERM=7.353) with the real measurement, compared to the Chumlea equation. **Conclusion:** The Rabito equation shows closer limits of agreement, higher level of concordance and better quality of estimation for weight and height in hospitalized Peruvian adults, observing variation in the estimation of weight for individuals with subscapular skinfold over 30 mm.

RESUMO

Introdução: O peso e a altura são medidas necessárias e essenciais para a identificação e o tratamento de pacientes com desnutrição ou risco nutricional. Porém, há situações clínicas que impedem a realização dessas medidas. As equações propostas para a estimativa foram criadas e validadas em outros países. O presente estudo tem como objetivo determinar a equação mais adequada para pacientes adultos peruanos. **Método:** Estudo comparativo, observacional e transversal, que incluiu pacientes adultos da unidade de medicina do Hospital General Jaén. As medidas antropométricas coletadas foram selecionadas de acordo com as equações de Chumlea e Rabito. A análise de Bland Altman e o Coeficiente de Correlação Intraclasse (ICC) foram usados para avaliar a concordância. A qualidade da estimativa foi avaliada pelos métodos Root Mean Square Error (RMSE) e Mean Relative Error (ERM). A significância estatística foi considerada em um valor de $p<0,05$. **Resultados:** Foram incluídos 41 pacientes, com idade média de 34,49 ± 12,55 anos. Nesses pacientes, 63,41% eram mulheres. O peso médio foi de 63,65 ± 10,29 kg, e a altura, de 158,70 ± 8,45 cm. A equação de Rabito apresentou limites de concordância mais estreitos (-7,06 a 6,83 cm), melhor concordância (ICC=0,908) e melhor ajuste de qualidade (RMSE=3,501; ERM=2,231) com a altura real, em comparação com a equação de Chumlea. Em relação ao peso estimado, a equação de Rabito obteve limites de concordância mais estreitos (-7,33 a 10,84 kg), melhor concordância (ICC=0,882) e melhor ajuste de qualidade (RMSE=4,902; ERM=7,353) com a medida real, em comparação com a equação de Chumlea. **Conclusão:** A equação de Rabito mostra limites de concordância mais estreitos, maior nível de concordância e melhor qualidade de estimativa de peso e altura em adultos peruanos hospitalizados, observando variação na estimativa de peso para indivíduos com dobra subescapular maior que 30 mm.

Unitermos:
Antropometria. Pesos e medidas corporais. Adulto. Altura.

Keywords:
Anthropometry. Body weights and measures. Adult. Height.

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INTRODUCTION

The first step in the nutritional care process can be considered the nutritional risk assessment. Its main objective is to identify those patients who are malnourished or at risk of developing malnutrition and who may benefit from nutritional treatment[1]. There are several tools to identify nutritional risk in hospitalized patients, among which the most relevant analyze anthropometric data. Their importance is given by their high predictive validity and sensitivity of more than 80% in patients with different issues[2]. It is known that the presence of nutritional risk in patients is associated with worsening disease, increased hospitalization and mortality[3].

Accordingly, weight and height are necessary and essential measurements for the identification and treatment of patients with malnutrition or nutritional risk. In addition, there are many therapeutic actions that require these measurements, such as protective mechanical ventilation, the use of vasoactive agents, inotropes, aminoglycosides, glycopeptides, anti-competitive drugs, or nutritional support[4]. However, there are also clinical situations that impede the taking of real weight and height due to poor or no mobility of the patient. The literature indicates that there are practical difficulties to perform these measurements in patients with severe health compromise[5] and errors can occur when weight and height are estimated visually[6,7].

Several authors have proposed mathematical equations for the estimation of weight and height. Of these, we can mention the models of Rabito et al.[8], based on the Brazilian population, and the models of Chumlea et al.[9], based on the North American population. The results of these equations could present a lower level of agreement with the real measurements of Peruvian adults, possibly due to phenotype differences[6,8,10-16].

Although the Peruvian Ministry of Health suggests the use of the Chumlea equation for the estimation of weight and height in adults through its Technical Guide for the Anthropometric Nutritional Assessment of the Elderly[17], we have not found recommendations for estimating these measurements in this age group[18]. Considering the importance of measuring weight and height, the objective of the present study is to determine the most appropriate equation to be used to estimate weight and height in hospitalized Peruvian patients.

METHODS

Study Design and Population

We performed a comparative, observational, prospective and cross-sectional study. We included all Peruvian adult patients hospitalized in the medicine unit of the Hospital General Jaén, during the period from March to April 2023. Patients whose stay was less than 24 hours, with foreign nationality, with physical disabilities, with edema or ascites, with amputations or fractures, pregnant patients, pediatric patients, older adults, or those who refused to participate were excluded.

Variables and Measurements

Anthropometric measurements were selected according to the Chumlea et al.[9], and Rabito et al.[8] equations for the estimation of weight and height (Box 1). Data collection was preceded by standardization of the researchers involved in the measurement procedures and techniques. Measurements were taken in the afternoon-evening after a 4-hour period of food intake.

Box 1 – Equations used in this study.

Equations for height estimation	
Authors	**Equation**
Rabito et al.[8]	MALE: 63,525-3,327(1)–0,06904(Age)+1,293 (EMB) FEMALE: 63,525-3,327(2)–0,06904(Age)+1,293 (EMB)
Chumlea et al.[9]	MALE: 1,88(AR)+71,85 FEMALE: 70,25+0,05(Age)+1,86(AR)
Equations for weight estimation	
Rabito et al.[8]	MALE: 0,5759 (CB)+0,5263(CA)+1,2452(CP)-4,8689(1)-32,9241 FEMALE: 0,5759 (CB)+0,5263(CA)+1,2452(CP)-4,8689(2)-32,9241
Chumlea et al.[9]	MALE: 0,98(CP)+1,16(AR)+1,73(CB)+0,37(PCS)-81,69 FEMALE: 1,27(CP)+0,87(AR)+0,98(CB)+0,4(PCS)-62,35

CP: calf circumference; AR: knee height; CB: arm circumference; PCS: subscapular skinfold; CA: abdominal circumference; EMB: half arm span.

Sex, age (years), height (m), weight (kg), subscapular skinfold (mm), abdominal circumference (cm), arm circumference (cm), half arm span (cm) and knee height (cm) were considered. All measurements were performed according to the guidelines of the International Society for the Advancement of Kin Anthropometry[19], using the following instruments: a scale with built-in SECA® brand measuring rod with maximum capacity of 220 kg and its division scale (50 g), measuring height (60-200 cm), minimum value of height per division (0,5 cm). Skinfolds were measured using a Slimguide brand caliper with 80 mm aperture and sensitivity of 1 mm. Perimeters were measured using a SECA® brand non-stretchable tape measure with a length of 205 cm and sensitivity of 0,1 cm.

Statistical Analysis

We used a database created in Microsoft Excel, which included demographic characteristics, clinical characteristics, and anthropometric data. The data were imported into the statistical program SPSS version 21. To evaluate the concordance between the estimates and the real measurements, a Bland-Altman analysis was performed, which included a Student's t-test analysis for one average.

With the same objective, we also evaluated the Intraclass Correlation Coefficient (ICC). The Root Mean Square Error (RMSE) and the Expected Relative Error (ERM) were used to evaluate the quality of the estimation between the real and estimated values. A p-value of less than 0,05 was considered statistically significant.

Ethical Considerations

Authorization was obtained from the management of the Hospital General Jaén and the Head of the Department of Medicine. The study was performed according to the protocols of the Declaration of Helsinki. All participants signed informed consent prior to taking measurements.

RESULTS

Of the seventy-nine adult patients identified, 38 did not meet the inclusion criteria; therefore, the study was conducted with 41 patients. The mean age of the participants was 34,49 ± 12,55 years, where 63,41% were women (n=26) and 36.58% were men (n=15). Average weight among participants was 63.65 ± 10.29 kg, and average height was 158.70 ± 8.45 cm.

In the total sample, the average for height measured by the direct method and estimated by the Chumlea equation and the Rabito equation were 158.70 cm, 163.48 cm and 158.82 cm, respectively. The values determined by the Rabito equation were closer to the real height compared to the Chumlea equation, whose mean estimates were farther from the real height, with a tendency to overestimate. The average weight measured by the direct method and estimated by the Chumlea equation and the Rabito equation was 63.65 kg, 59.22 kg and 61.89 kg, respectively. The values determined by the Rabito equation were closer to the real weight in most cases, compared to the Chumlea equation, whose mean estimates were farther from the real weight, with a tendency to underestimate (Figure 1).

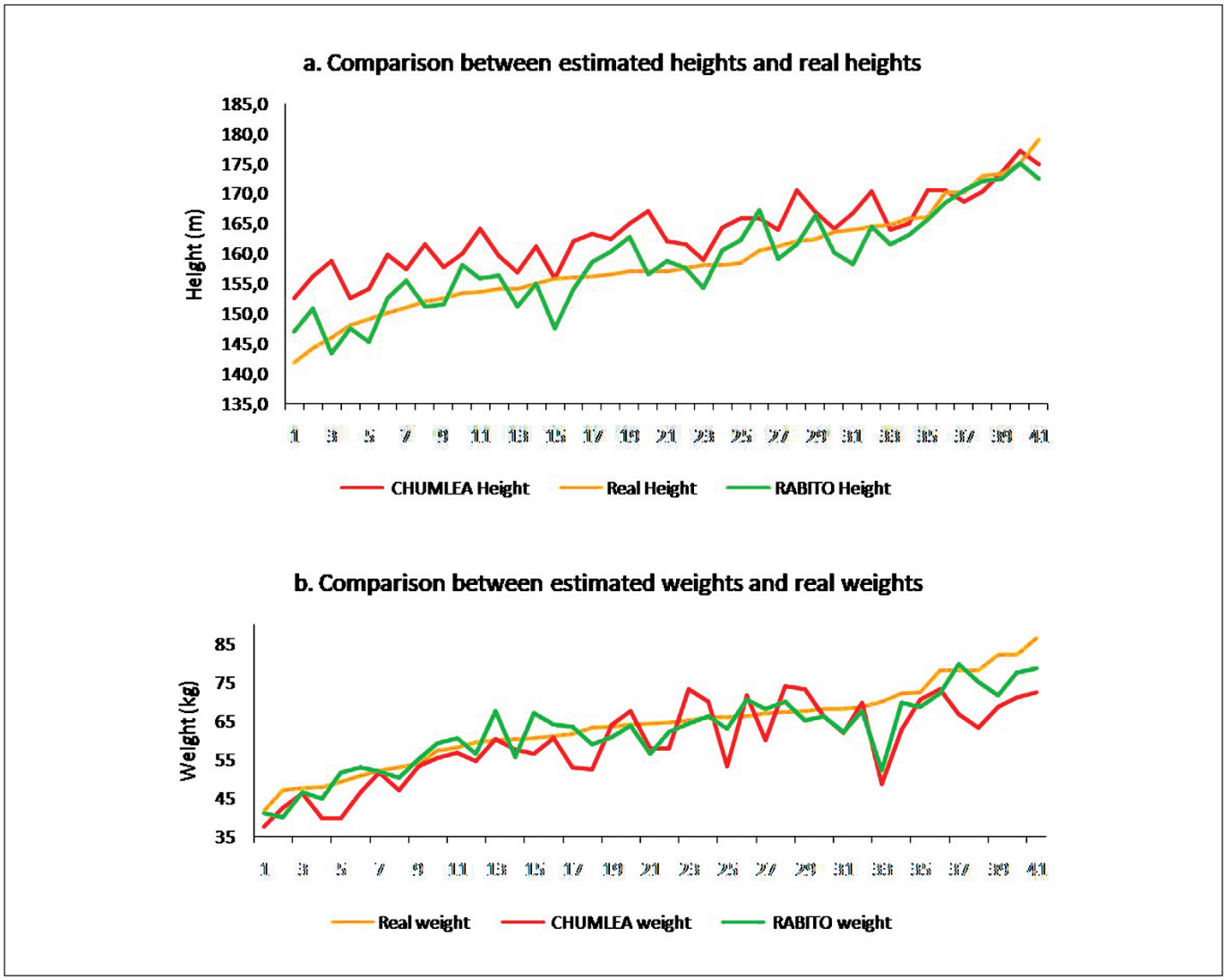

Figure 1 - *Lines graph with actual and estimated values for height and weight.*

Regarding height, the mean difference by Bland-Altman analysis ranged from -12.76 to 3.2 cm for the Chumlea equation and from -7.06 to 6.83 cm for the Rabito equation. Both confidence intervals included the zero value; however, the amplitude of the limits of agreement was closer for the Rabito equation.

The ICC between the real height and the height estimated by Chumlea was 0.697 (α=0.05), indicating a high degree of agreement (Figure 2a). The estimation by Rabito had an ICC of 0.908 (α=0.05), indicating a very high degree of agreement (Figure 2b).

In relation to weight, the average difference by Bland-Altman analysis resulted between -8.17 and 17.02 kg for the Chumlea equation and -7.33 to 10.84 kg for the Rabito equation. Both confidence intervals included the zero value. However, the amplitude of the limits of agreement was closer for the Rabito equation.

The ICC between the actual weight and the weight estimated by Chumlea was 0,743 (α=0,05), corresponding a high grade of agreement (Figure 3a). The estimation by by Rabito had an ICC of 0.882 (α=0,05), indicating a very high grade of agreement (Figure 3b).

The averages of the weight and height values obtained by the direct method, the Chumlea equation and the Rabito equation, classified by sex and body measurements, are shown in Tables 1 and 2.

In addition, the ICC between the real weight and the weight estimated by each equation was compared according to sex and body measurements. We found that the correlation coefficient was higher for the Rabito equation (when compared to the Chumlea equation) in almost all analyses (high and very high correlation), except for patients with subscapular skinfold over 30 mm, in which both equations presented the same coefficient (0.517), corresponding to a moderate correlation.

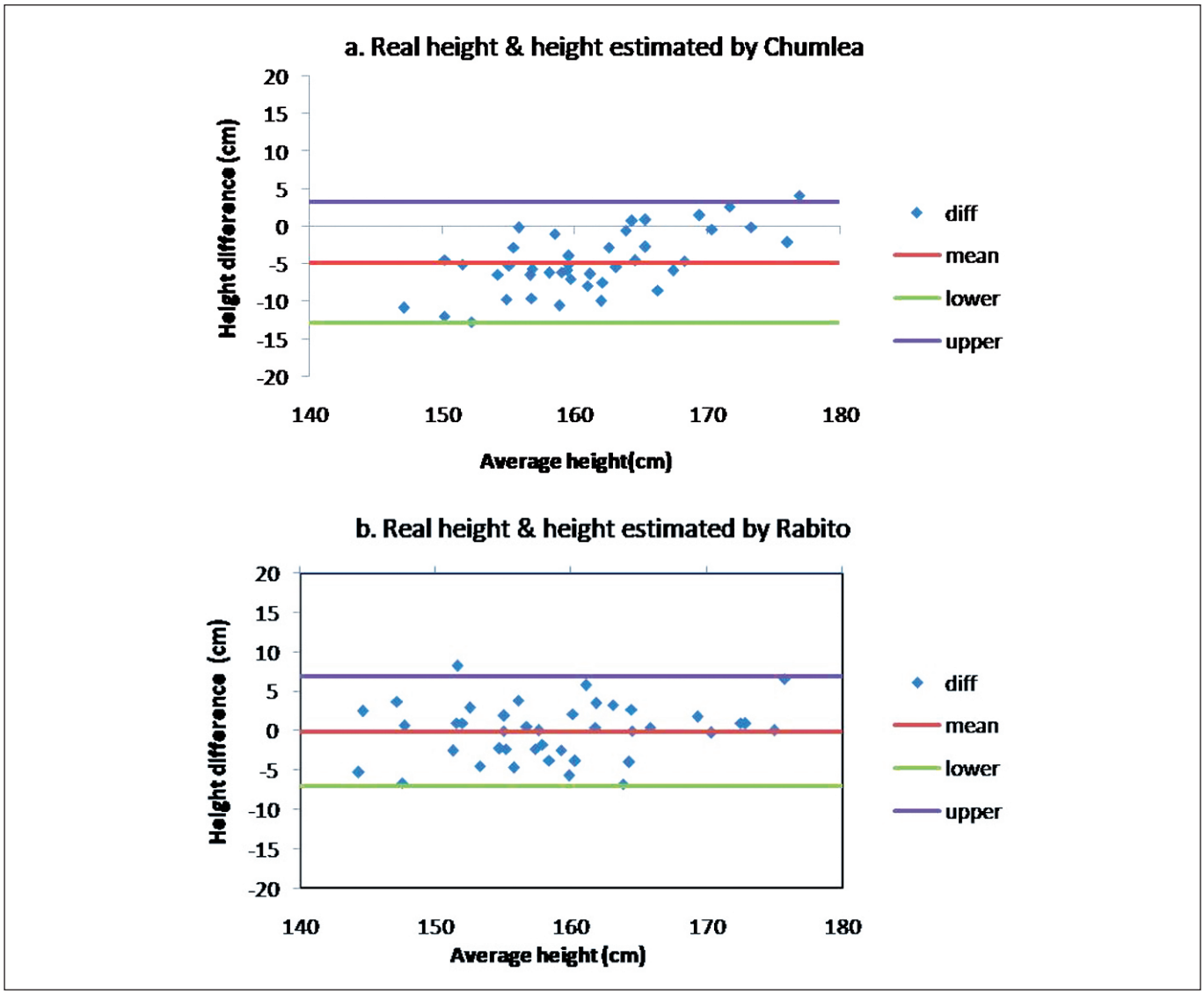

Figure 2 - *Bland-Altman Plot grafic for heights.*

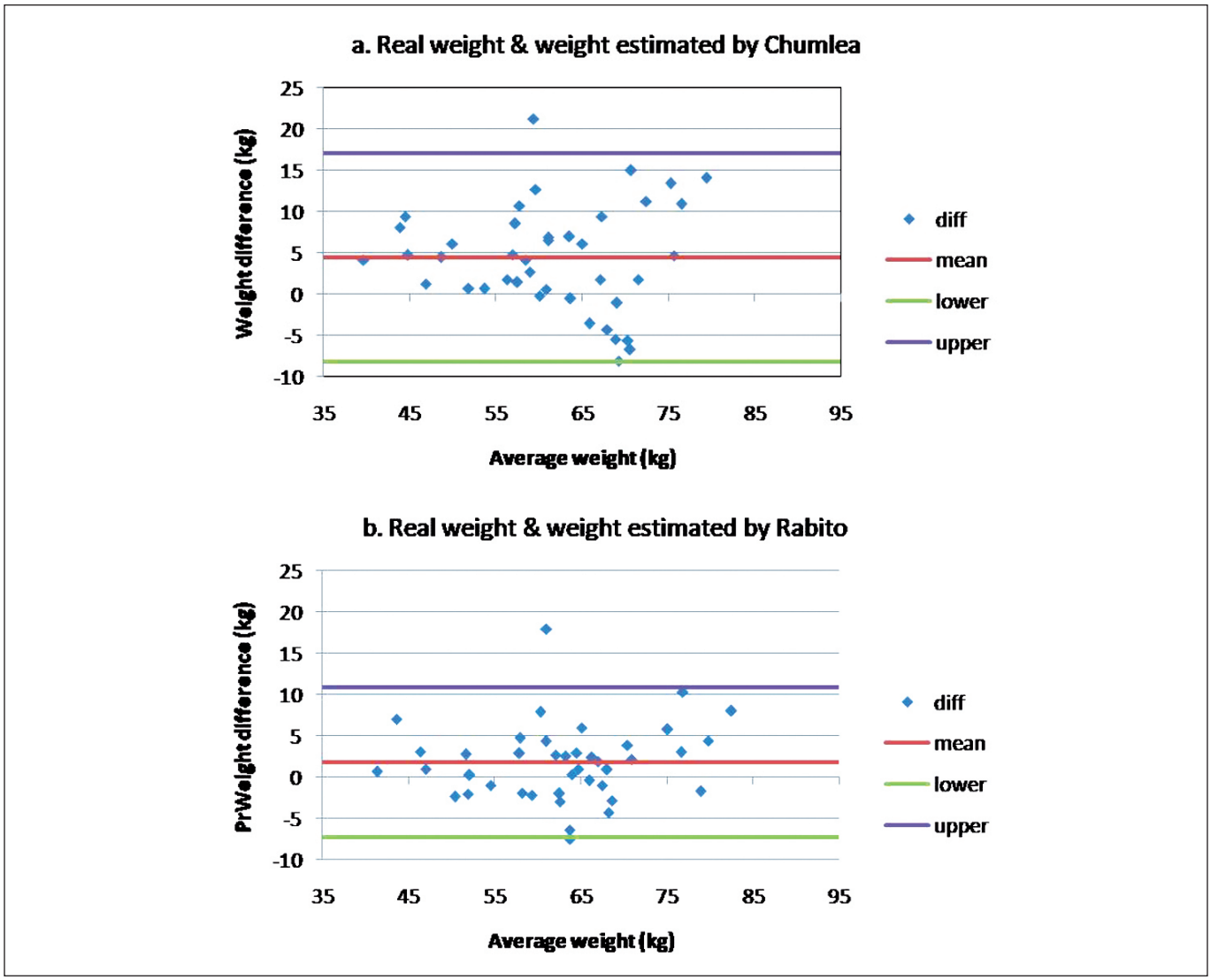

Figure 3 - *Bland-Altman Plot grafic for weights.*

Table 1 – Average of Weight, Intraclass Correlation Coefficient (ICC) and P-value, obtained by estimation formulas compared to real weight, stratified by sex and body measurements.

Authors	Method	Average	ICC	P Value of ICC
According to sex				
	Real Weight	63,06	-	
Female (n=26)	Rabito equation	60,82	0,884	
	Chumlea equation	57,25	0,760	0,05
	Real Weight	64,67	-	
Male (n=15)	Rabito equation	63,76	0,873	
	Chumlea equation	62,64	0,624	
According arm circumference				
	Real Weight	61,81	-	
≤ 30 cm (n=35)	Rabito equation	60,45	0,880	
	Chumlea equation	56,96	0,730	0,05
	Real Weight	74,40	-	
> 30 cm (n=6)	Rabito equation	70,30	0,698	
	Chumlea equation	72,44	-0,283	

Table 1 – Average of Weight, Intraclass Correlation Coefficient (ICC) and P-value, obtained by estimation formulas compared to real weight, stratified by sex and body measurements.

Authors	Method	Average	ICC	P Value of ICC
According subscapular skinfold				
	Real Weight	57,36	-	
≤ 15 mm (n=15)	Rabito equation	55,21	0,869	
	Chumlea equation	50,04	0,635	
	Real Weight	66,8	-	
> 15 and ≤ 30 mm (n=20)	Rabito equation	64,86	0,846	0,05
	Chumlea equation	63,24	0,639	
	Real Weight	68,87	-	
> 30 mm (n=6)	Rabito equation	68,72	0,517	
	Chumlea equation	68,79	0,517	
According knee height				
	Real Weight	62,37	-	
≤ 50 cm (n=29)	Rabito equation	61,59	0,928	
	Chumlea equation	57,58	0,796	0,05
	Real Weight	66,74	-	
> 50 cm (n=12)	Rabito equation	62,63	0,676	
	Chumlea equation	63,19	0,451	
According half arm span				
	Real Weight	62,65	-	
≤ 80 cm (n=23)	Rabito equation	61,44	0,886	
	Chumlea equation	56,7	0,739	0,05
	Real Weight	64,92	-	
> 80 cm (n=18)	Rabito equation	62,47	0,879	
	Chumlea equation	62,45	0,742	
According to abdominal circumference				
	Real Weight	61,51	-	
≤ 100 cm (n=35)	Rabito equation	59,69	0,848	
	Chumlea equation	58,05	0,763	0,05
	Real Weight	76,13	-	
> 100 cm (n=6)	Rabito equation	74,74	0,756	
	Chumlea equation	66,06	0,388	

When comparing the ICC between the real height and the height estimated by each equation, according to sex and body measurements, we found that the correlation coefficient was higher for the Rabito equation (when compared to the Chumlea equation) in all analyses (high and very high correlation).

The evaluation of the quality of adjustment according to the ERM shows that the Rabito equation for weight has a good estimation (ERM=7.353), while the Chumlea equation has a regular estimation quality (ERM=11.449). When it was analyzed according to sex, there was an improvement in the quality of adjustment for male patients in both equations (Rabito ERM=4.876; Chumlea ERM=8.410). According to the ERM for height, both equations presented very good quality of fit (Rabito ERM=2.231; Chumlea ERM=3.857). When analyzed by sex, there was an improvement in the quality of fit for male patients in both equations (Rabito ERM=2.064; Chumlea ERM=2.71; Table 3).

When considering the quality of fit according to the RMSE coefficients, the Rabito equation for weight is very good (RMSE=4,902), while the Chumlea equation is good (RMSE=7,738). When the fit was analyzed according to sex, there was an improvement in the quality of fit for male patients in both equations (Rabito RMSE=3.153; Chumlea RMSE=5.672). The RMSE for height with the Rabito equation is very good (3.501), while the Chumlea equation is good (6.243). When analyzed according to sex, there was an improvement in the quality of fit for male patients in both equations, both being very good (Rabito RMSE=3.390; Chumlea RMSE=4.385; Table 3).

Table 2 – Average of height values, Intraclass Correlation Coefficient (ICC) and P value, obtained by estimation formulas compared to real height, stratified by sex and body measurements.

Authors	Method	Average	ICC	P Value of ICC
According to sex				
	Real Height	154,37	-	
Female (n=26)	Rabito equation	154,28	0,789	
	Chumlea equation	160,48	0,444	0,05
	Real Height	162,22	-	
Male (n=15)	Rabito equation	166,68	0,843	
	Chumlea equation	168,68	0,733	
According arm circumference				
	Real Height	158,5	-	
≤ 30 cm (n=35)	Rabito equation	158,67	0,911	
	Chumlea equation	163,24	0,719	0,05
	Real Height	159,92	-	
> 30 cm (n=6)	Rabito equation	159,66	0,885	
	Chumlea equation	164,88	0,451	
According subscapular skinfold				
	Real Height	159,13	-	
≤ 15 mm (n=15)	Rabito equation	157,36	0,892	
	Chumlea equation	162,39	0,779	
	Real Height	160,15	-	
> 15 and ≤ 30 mm (n=20)	Rabito equation	161,54	0,913	0,05
	Chumlea equation	165,15	0,718	
	Real Height	152,85	-	
> 30 mm (n=6)	Rabito equation	153,39	0,884	
	Chumlea equation	160,62	0,179	
According knee height				
	Real Height	154,84	-	
≤ 50 cm (n=29)	Rabito equation	155,46	0,795	
	Chumlea equation	160,54	0,438	0,05
	Real Height	168,04	-	
> 50 cm (n=12)	Rabito equation	166,95	0,894	
	Chumlea equation	170,57	0,579	
According half arm span				
	Real Height	153,35	-	
≤ 80 cm (n=23)	Rabito equation	153,27	0,738	
	Chumlea equation	159,70	0,379	0,05
	Real Height	165,55	-	
> 80 cm (n=18)	Rabito equation	165,90	0,827	
	Chumlea equation	168,30	0,671	
According to abdominal circumference				
	Real Height	159,40	-	
≤ 100 cm (n=35)	Rabito equation	159,50	0,906	
	Chumlea equation	163,75	0,739	0,05
	Real Height	154,67	-	
> 100 cm (n=6)	Rabito equation	154,83	0,901	
	Chumlea equation	161,92	0,318	

Table 3 – Evaluation of estimating equations according to RMSE & ERM methods.

For weight	Method	RMSE	ERM
Total sample (n=41)	Rabito equation	4,902	7,353
	Chumlea equation	7,738	11,449
According to sex			
Female (n=26)	Rabito equation	5,671	8,458
	Chumlea equation	8,710	12,880
Male (n=15)	Rabito equation	3,153	4,876
	Chumlea equation	5,672	8,410
For weight			
Total sample (n=41)	Rabito equation	3,501	2,231
	Chumlea equation	6,243	3,870
According to sex			
Female (n=26)	Rabito equation	3,563	2,329
	Chumlea equation	7,098	4,705
Male (n=15)	Rabito equation	3,390	2,064
	Chumlea equation	4,385	2,716

DISCUSSION

In the present study, the mean age of the hospitalized Peruvian adult patients was 34.49 ± 12.55 years, a value close to that reported by Melo et al.[13] and Rodrigues et al.[20] in their research carried out in Brazil. Regarding to sex, in our sample, 63,41% of participants were women and 36,58% were men, a similar reality to that reported by Rodrigues et al.[20], where the female sex predominated (58%), but much higher than that reported by Melo et al.[13], where women represented 47,9% of the sample.

Our results show that, in the analysis of the equations for estimating height in hospitalized Peruvian adult patients, both for men and women, the Rabito equation obtained better concordance (ICC=0.908) and better quality adjustment (RMSE=3.501; ERM=2.231) with the real measurements, when compared to the Chumlea equation. This result coincides with a study by Matos et al.[21], in Peru, where they indicated the Rabito was the best equation for estimating real height, based on the RMSE of 3.64 for men and 3.82 for women, very similar to that found in our study (3.390 for men and 3.563 for women). This is in partial agreement with Melo et al.[13], as they mentioned that the Rabito equation showed closer measures of height for females, while for males, the Chumlea equation showed measures closer to the real measurements. In our research, the Chumlea equation presented an improvement in its estimation for men both in ICC, RMSE and ERM. However, the Rabito equation was better in all cases.

In general terms, the Chumlea equation showed a tendency to overestimate the height in Peruvian adult patients. Rodrigues et al.[20] reported that, for women adults, the Chumlea equation overestimated height but measured adequately in men. Melo et al.[13], on the other hand, pointed out that the Chumlea equation underestimates the real height of women.

In relation to the estimation of weight in Peruvian adult patients, both for men and women, the Rabito equation obtained better concordance (ICC=0.882) and higher quality adjustment (RMSE=4.902; ERM=7.353) to the real measurements when compared to the Chumlea equation. This is consistent with that reported by Matos et al.[21], where the Rabito equation was the closest to estimating the real weight, based on the RMSE of 4.38 for males and 4.36 for females, a very similar finding to that in our study (3.153 for males and 5.671 for females). Melo et al.[13] mentions that the Rabito equation shows closer measures of weight for males, however, in their study they found that for females, the Chumlea equation showed measures closer to the real one. In contrast to our results, a study performed in Brazil showed a high concordance for weight estimation with the Chumlea equation ($r=0.92$; $p<0.0001$)[20]. However, this study did not use the Rabito equation, and so we could not rule out that they could have found a higher correlation with this equation.

In general, in our study, the Chumlea equation showed a tendency to underestimate the weight of hospitalized Peruvian patients. This partially contrasts with the results of Melo et al.[13], since, in their study, the Chumlea equation overestimated the real weight in men but underestimated the real weight in women.

In addition, no variations were observed between the real weight and the weight estimated by Rabito, according to body measurements, except in patients with a higher level of subscapular skinfold (>30 mm). In these patients, the ICC decreased to a value of 0.517 (from very high to moderate), while for the Chumlea equation, greater variations were observed, decreasing its level of concordance from high to moderate (for cases of knee height over 50 cm and subscapular skinfold over 30 mm) or from high to low (for

cases of abdominal circumference over 100 cm) and even to negative concordance (for arm circumference over 30 cm). The level of concordance between the height estimated by Rabito and the real height remained between high and very high in all cases (according to body measurements). For the Chumlea equation, variations of concordance were observed from high to low (in cases of arm circumference under 30 cm, subscapular skinfold over 30 mm, knee height under or equal to 50 cm, half arm span under or equal to 80 cm). Few studies have subdivided their population according to body measurements, which makes comparison with our results difficult.

Therefore, according to what was observed, the implementation of the weight and height estimation equation proposed by Rabito in the clinical practice of hospitalized Peruvian adults could be suggested as an alternative in the estimation of these measurements in prostrate patients, using it with caution in patients with subscapular skinfold over 30 mm, due to its lower level of concordance.

One of the strengths of the present study is the access to the real weight and height of the patients, which helped to make objective comparisons with the real value and not with other estimation equations. The fact that these were hospitalized patients increases the clinical validity of our results.

CONCLUSION

The equation proposed by Rabito showed a higher level of agreement according to ICC and a better estimation quality according to RMSE and ERM, with the real measurement in hospitalized Peruvian adults, when compared to Chumlea's equation. However, it should be taken into consideration that the degree of agreement for weight estimation decreases for an individual with a subscapular skinfold over 30 mm. In addition to this, it should be noted that these equations can only provide the exact value of measurements in some cases. However, they can be used as a parameter for nutritional follow-up.

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