Journal of Aging and Innovation

Marques J., Pinho-Reis C. (2022) Validity of Chumlea's two variable weight prediction equations in elderly patients in Portugal, Journal of Aging & Innovation, 11 (2): 63 - 74

♦ ARTIGO ORIGINAL

Validity of Chumlea's two variable weight prediction equations in elderly patients in Portugal

Validade das duas equações de predição de peso variável de Chumlea em idosos em Portugal

Validez de las dos ecuaciones de predicción de peso variable de Chumlea en pacientes ancianos en Portugal

João Nuno Alves do Vale Marques[1], Cíntia Pinho-Reis[2]

[1] Bsc, Porto University, Faculty of Sciences, Porto, Portugal. , [2] MsC, University Fernando Pessoa Hospital, Long-Term Care Unit, S. Cosme, Portugal.

Corresponding Author: joaonavmarques@gmail.com

Contribuitors

João Marques was responsible for the data collection, manuscript writing, results organization and statistical analysis. Cíntia Pinho-Reis assisted with manuscript review. All the authors are in agreement with the presented manuscript and declare that this work has not been published elsewhere.

Funding

There was no funding whatsoever associated to the making of this study.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

On 09/08/2021, the Casa de Saúde São Mateus - Hospital Ethics committee approved the making of this study. The approval number associated to this project is nº003.

Abstract

Introduction: Body weight is one of the most important clinical parameters in assessing patients' nutritional status. Since elderly patients are more likely to be bedridden, weight prediction equations are very important in estimating patients' weights. Thus our aim to clarify if Chumlea's two variable weight prediction equations are valid in the portuguese population.

Methods: The sample consisted of 100 hospitalized patients (58 male and 42 female) age equal or over 65 years old. To obtain real weight (RW), all patients were weighed in the same hospital scale, while for estimated weight (EW), calf and mid upper-arm circumferences were taken and added to Chumlea's equations. Patients with no orthostasis were measured in a wheelchair and later their weight was subtracted. Height was measured using a stadiometer and patients with no orthostasis were measured while in bed. Real BMI (RBMI) was calculated with the patients' RW and hight, while estimated BMI (EBMI) was calculated with the patients' EW and hight.

Results: In the male sample, EW underestimated patients' RW by a mean of -3.9±5.2kg (r=0.848, p<0.001), and EBMI was 1.5kg/m2 (r=0.814, p<0.001) lower than RBMI. In the female sample, EW underestimated patients' RW by a mean of -4.7±6.6kg (r=0.871, p<0.001), and EBMI was 2.0kg/m2 (r=0.873, p<0.001) lower than RBMI.

Conclusion: Without the use of weight prediction equations most elderly bedridden patients would not have their weights taken. Hospitals should use Chumlea's equations when specific anthropometric material is not available and always considering the bias reported in this study between RW and EW.

Key Words: elderly, weight, Chumlea

Introduction

Body weight (BW) is one of the most important measures to obtain throughout patient admission and treatment process in any hospital setting. It is a reliable initial representation of every patient's nutritional status, since it is undeniably related to edema, nutritional disorders or malnutrition. By detecting and treating malnutrition with correct BW measuring, one may decrease lengths of hospital stay, mortality, and also hospital costs related to patient treatment(1,2). During patient admission, pharmacological treatment is often prescribed to its full extent, with only minor readjustments in dosage being made later on, according to disease development. Drug dosage is often calculated taking into account the patient's BW (3), thus emphasizing the importance of correct weight measuring.

In spite of its importance, BW is often overlooked or not correctly measured during hospital admission or reevaluation (4,5). This is due to a myriad of causes, such as non-ambulatory or aggressive patients (6,7), faulty weighing equipment (6,8), and also lack of staff training in accurately using basic weighing equipment (9). Elderly patients are amongst the most affected by these hindrances, because of natural causes these are the ones who are more likely to be bed ridden or simply unable to walk. However, some of these obstacles can be overcome with the use of weight predictive equations, which in some cases can be very accurate.

The use of predictive equations has many disadvantages, one of them being the specificity of the population to which that equation was created. When it comes to elder individuals, there are not many equations which surpass the accuracy in BW prediction as shown by Chumlea and his colleagues (10). In this article, three prediction equations were created, using two (1.1 to 1.4 kg of mean difference), three (0.3 to 1.8 kg of mean difference) and four (-1.9 to 0.1 kg of mean difference) variables. In total, the mean difference between actual and predicted weight ranged from 0.1 to 1.8 kg. This equation however was made with a population sample resident in Ohio, United States of America, meaning that it might not be suitable for use in another country due to population differences. Nonetheless, there have been studies that have validated Chumlea's equation in other countries, such as Spain (11), but few have been done in Portugal.

Lately Portugal has been on the rise of nutrition care in Hospitals. This has only been made possible with an ever growing number of registered dietitians in Primary Heath Care establishments. This rise of qualified professionals with good anthropometric background makes it a necessity to have validated BW prediction equations towards the population in question. As such, the goal of this study is to assess Chumlea's two variable equations' (for male and female) validity, for prediction of body weight for further use in clinical settings in elderly patients from the center of Portugal.

Methods

This study was conducted in the convalescence unit of a Portuguese Home Health Care in Viseu, Portugal. While some patients in the study were from Viseu, most came from adjacent hospitals from regions adjacent to Viseu, mainly from Guarda. The study sample consisted of 58 white male subjects and 42 white female subjects, 65 to 101 years old. Inclusion criteria were: age equal or over 65 years old and ability to answer questions. Exclusion criteria were as follows: patients with severe edema, ascites, moderate or severe cognitive impairment and limb amputation. Both authors are strongly committed to the "Principles of Transparency and Best Practice in Scholarly Publishing" issued by the Committee on Publication Ethics. In accordance to this, only after approval by the ethics commission of the study institution did this study take place. Each subject was handed a consent agreement form and only after deliverance of said form was he/she entered as a study participant.

Most of the participants were ambulatory and able to walk to the measuring area, while those that were nonambulatory were weighted with the wheelchair and later its BW was subtracted to the total weight. BW was measured with a KERN MWA 300K-1M scale, calf circumference (CC) and mid-upper arm circumference (MUAC) were measured with a standard issue flexible measuring tape and height was measured with a SECA 213 stadiometer. Nonambulatory participants' height was measured by marking the bed sheet at the top of the patient's head and at the bottom of the heel, and measuring with a measuring tape the distance between the two marks while the bed was completely horizontal. All measurements and weightings were done by the same dietitian within the guidelines of International Standards for Anthropometrical Assessment by ISAK. All measurements were taken three times and the average of those measurements was recorded. Every patient was measured with either no clothes on the measurement sites, or with very light clothing on them. BMI was also recorded from each patient. Height measurements, real BW and estimated BW were used to obtain BMI. Two different BMI measurements were recorded, one according to real BW (RBMI) and another according to estimated BW (EBMI).

Chumlea's two variable equations used in this study to estimate male and female BW were as follows:

(MUAC*1.63) + (CC*1.43) - 37.46   [Equation for females]

(MUAC*2.31) + (CC*1.5) – 50.10   [Equation for males]

All data was recorded and processed using Microsoft Office Excel 2007(R) software. Correlation between real BW and estimated BW, and between RBMI and EBMI was analyzed through Interclass Correlation Coefficient (ICC) and Bland-Altman Plots. A *t*-student test was also done. Standard error of estimate was not used, unlike in Chumlea's study, since this study did not have multiple sample populations.

Results

Regarding the male sample, a mean age of 76±7.2 years was recorded. Its mean stature was 164.6±5.6 cm. Concerning the measurements, mean MUAC and CC measurements were of 27.3±2.9 cm and 33.0±3.0 cm respectively. Mean real weight was 66.05±9.3 kg, while estimated weight was 62.14±9.4 kg, thus representing a -3.9 kg bias between the two variables. Mean RBMI for this sample was 24.4±2.9 kg/m2, while mean EBMI was 22.9±3.3 kg/m2. Correlation between real BW and estimated BW was indeed good, r=0.848 (p<0.001).

Relative to the female sample, a mean age of 80±7.3 years was recorded. Its mean stature was 151.5±4.7 cm. Regarding the measurements, mean MUAC and CC measurements were of 28.9±3.9 cm and 33.5±4.0 cm respectively. Mean real weight was 62.3±13.5 kg, while estimated weight was 57.7±11.2 kg, thus representing a -4.7 kg bias between the two variables. Mean RBMI for this sample was 27.2±6.0 kg/m2, while mean EBMI was 25.2±5.0 kg/m2. Similar to what was seen in the male sample, correlation between real BW and estimated BW was indeed good, r=0.871 (p<0.001). By observing figure 1, the individual differences in male and female estimated and real weight demonstrated in a Bland-Altmann plot can be seen. Another Bland-Altmann plot (figure 2) demonstrates the correlation between RBMI and RBMI. Further correlation between male and female samples in real and estimated weights and BMIs can be closely appreciated in table 1.

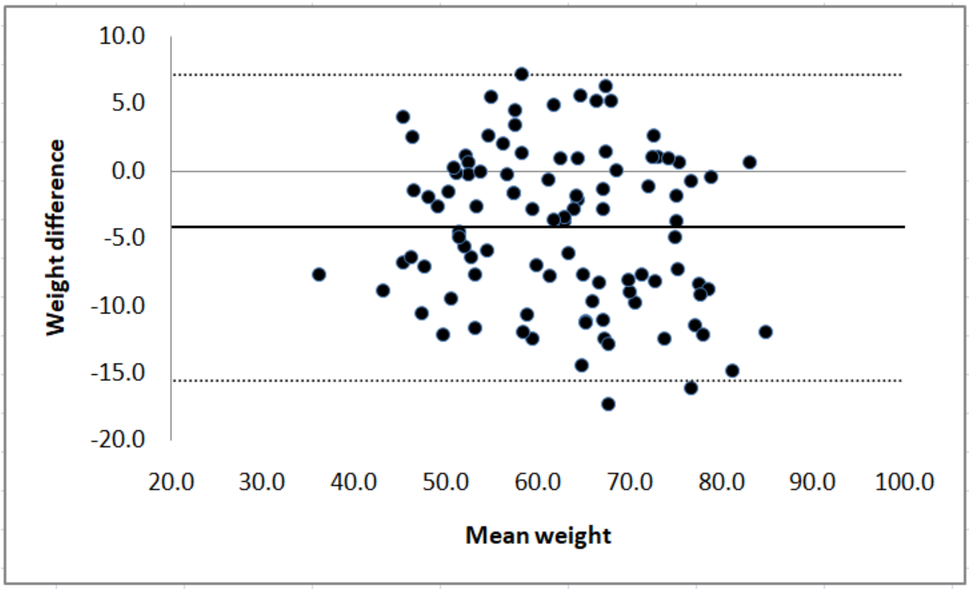

Figure 1 - Shows both the mean between real and estimated weights and the difference between both of these variables within the population. Since in most cases weight is underestimated, it's mean bias is -4.2±5.8 kg. In this plot a few outliers were detected since some values were out of the upper and lower limits of agreement, shown within the plot by two dotted lines.

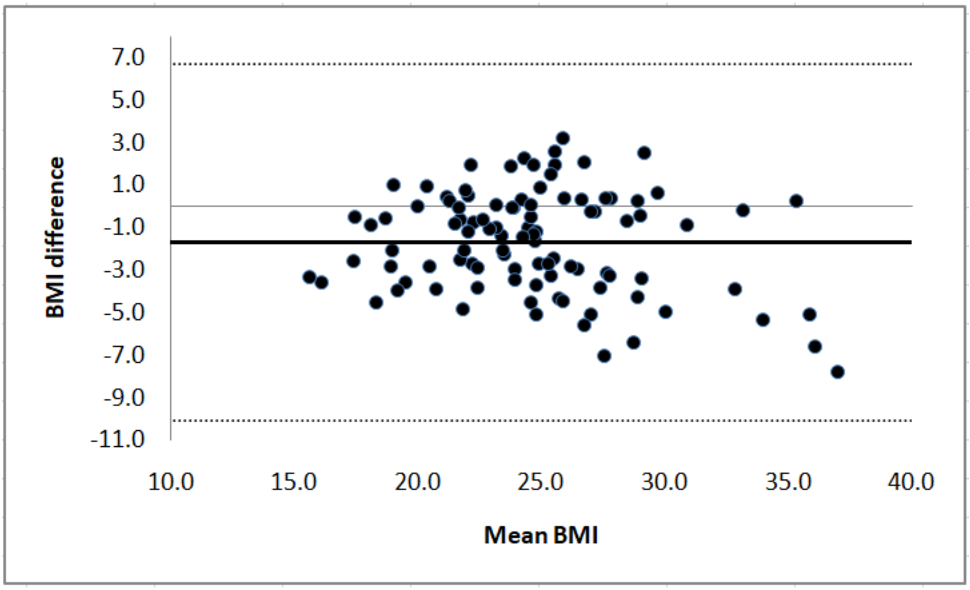

Figure 2 - Shows both the mean between real and estimated BMI and the difference between both of these variables within the population. Since in most cases BMI is underestimated, it's mean bias is -1.7±4.3 kg/m2. In this plot no outliers were detected since all the values were within the upper and lower limits of agreement, shown within the plot by two dotted lines.

		Mean(kg)	SD	Mean difference(kg)	ICC	p
Male	RW	66.1	9.3	-3.8	0.851	<0.001
	EW	62.1	9.4			
	RBMI	24.4	2.9	-1.5	0.818	
	EBMI	22.9	3.3			
Female	RW	62.3	13.5	-4.7	0.874	<0.001
	EW	57.7	11.2			
	RBMI	27.2	6.0	-2.0	0.873	
	EBMI	25.2	5.0			

Table 1 - Means of the differences between estimated equation weight and real weight.

Discussion

This research article centers itself in Chumlea's equations among others mainly due to three reasons: relative accuracy of equations, specificity of population age and condition and widespread knowledge of this author's works.

There are many other well known equations that estimate patient weight(12–15), however many of these use height or skinfolds. Since patients who are bedridden cannot have their heights properly measured, the practitioner would also have to use height estimation equations or less precise height measuring techniques to acquire the patient's height, therefore turning those weight equations even more imprecise. As for the measuring of skinfolds, the first catch lies in the acquisition of material to take skinfold measurements, which are not available in every hospital such as the one where this study was conducted and others(12). A way to circumvent this is to visually estimate the patient's weight or just record the patient's own reported weight. This is the fastest and cheapest way to record a patient's weight, but can also be a less precise method. Some studies however found that a patient's own reported weight is somewhat a more precise method than many equations(7,8,16,17). While visual weight estimation has been reported to have a relative small bias in comparison to real weight, it should be considered that this might be because of a tendency to underestimate weight in heavier patients and overestimate weight in light patients, which tends to cancel itself out, giving out a mean that is close to the patients' real weight due to uniform discrepancies in estimation(7).

Relative to Chumlea's article findings, in the table 3 of his article we can see that his estimated weights in the male samples were higher than the real weights, from 1.4kg (cross-validation sample) to 1.5kg (clinical-validation sample), while in his female samples this difference ranged from 1.5kg (cross-validation sample) to 4.6kg (clinical-validation sample). In this article we found that estimated weights in both samples were lower than recorded real weight by -3.8kg in the males and -4.7kg in females. These types of underestimation could also be seen in several other articles that validated Chumlea's equations(11,18–22). In fact, Chumlea's small sample sizes (18 individuals in the cross-validation sample and 17 in the clinical sample) undermine the validity of his means and could provide an explanation between the differences found in this study and his. This might also be an example of how population differences can play a big role in equation validity. Even simple equations with only one variable can become invalid if used on different populations. Marieke(19) shows how anthropometric equations developed for and from the American population are not to be promptly considered valid within the European population. Marieke's study(19) however tried to validate an equation meant for all ages on a solely elderly population, without having the ability to check for edema as ascites in their participants. Another example of this is a study made on Mexican women, using Chumlea's two variable equations(21). It would be logical to theorize that population differences could be small in countries close to another, however this study proves that much to likeness of this study, anthropometric population differences differ greatly even between neighboring populations, thus heightening the importance of creating specific anthropometric equations.

Development of specific population estimation equations is one of the best ways of ensuring the most precise weight estimations(12,15,23). A major study using the Nutrition UP 65 population sample was done to create weight prediction equations for the elderly in Portugal. Ultimately this proved to be the most precise way to estimate weight, since the derived equations are the most precise to ever have been tested in the Portuguese elder population(23). These equations however required the use of skinfold calipers, which are not available at every hospital, thus highlighting the need for continuous validation of other simpler equations or creation of new ones without the use of specific and expensive equipment.

The weight differences found in this current study between EW and RW also meant a significant difference between EBMI and RBMI. It is worthy of note that in Portugal it is required by law to use the NRS 2002 tool in every public hospital within 24h of patient admission(24). To that end, as shown by figure 2, there were a significant number of participants that according to the NRS 2002 tool could have wrongly been considered at risk of malnutrition (<20.5kg/m2). Similar BMI differences were found in studies that also validated Chumlea's equations on their populations(11,22,25).

In hospital settings, patient's health and consequent recuperation is the ultimate goal. To reach this goal, some patients are prescribed narrow therapeutic drugs. Some of these drugs are dosed according to the patients' weights, such as renally excreted drugs (heparin, enoxaparin and gentamicin - that should often be calculated per unit bodyweight), thus implying the need for correct patient weight recording. There are already several studies that reported unsuccessful procedures of this kind in hospitals. One reported example is the failure to weight patients who were taking anticoagulant drugs, which resulted in a much higher rate of hemorrhage than in those who were weighted prior to drug administration. Furthermore, in those patients who had displayed hemorrhaging, a large percentage of them had major bleedings and some had renal impairment(6,26). In another study, a total of 236 patients received antibiotics, and 86 of these patients that received one or more antibiotics (most often vancomycin) that required therapeutic dosing and monitoring based on weight. 39% of the patients who had received these types of antibiotics did not have their weights recorded(5). Another study found that even in patients who were correctly weighted, the correct dosage was prescribed only about half of the time(7).

The lack of patient weight recording is already something well reported within the literature, has had been stated before in this article, however it seems that weight recording is age oriented. Hospitals' weight recording practices were tested through a five years study where only 20.3% of patients were weighed during admission. However there were significant variations in weight recording practices in the different screened wards. While almost every patient (94.3%) in the pediatric ward had been weighed on admission, only a very small percentage of 4.3% of patients admitted to an aged care ward had been weighted(4). This could be linked to another article developed in Portugal, that reported high rates of malnutrition or risk of malnutrition, and found that the patients in risk of malnutrition were mostly the elderly that were already hospitalized for a long period of time(27). Ultimately this leads to perpetualization of lengthened hospital stays, since malnourished patients have increased lengths of hospital stay.

Conclusion

Elderly patient weight recording is of great importance. Not only are elders more likely to be on therapeutic drugs than other age classes, but they are also bound to have prolonged hospital stays. While patient weighing isn't readily available in most hospitals, and in turn these cannot afford expensive anthropometric materials, weight estimation equations should continue to be researched for extensive use within each population. Chumlea's equation proved to have significant bias when predicting the weight of the Portuguese population. To that end, it was considered that if a hospital does not have the materials or means to apply Guerra's equations, it could use Chumlea's two variable equations providing they ponder it's bias in the Portuguese population.

References

1. Barker LA, Gout BS, Crowe TC. Hospital malnutrition: Prevalence, identification and impact on patients and the healthcare system [Internet]. Vol. 8, International Journal of Environmental Research and Public Health. 2011 [cited 2021 Apr 6]. p. 514–27. Available from: www.mdpi.com/journal/ijerph

2. Ruiz AJ, Buitrago G, Rodríguez N, Gómez G, Sulo S, Gómez C, et al. Clinical and economic outcomes associated with malnutrition in hospitalized patients. Clin Nutr. 2019 Jun 1;38(3):1310–6.

3. Cheymol G. Effects of obesity on pharmacokinetics: Implications for drug therapy. Clin Pharmacokinet [Internet]. 2000 [cited 2021 May 17];39(3):215–31. Available from: https://pubmed.ncbi.nlm.nih.gov/11020136/

4. Lambert K, Ferguson A, Meletis M, Charlton K. How frequently are patients weighed in hospital ? Results from a five-year cross-sectional audit of clinical practice in nine hospitals. Clin Nutr ESPEN. 2020 Apr 1;36:157–61.

5. Charani E, Gharbi M, Hickson M, Othman S, Alfituri A, Frost G, et al. Lack of weight recording in patients being administered narrow therapeutic index antibiotics: A prospective cross-sectional study. BMJ Open [Internet]. 2015 Apr 2 [cited 2021 May 17];5(4). Available from: /pmc/articles/PMC4390734/

6. Hilmer SN, Rangiah C, Bajorek B V., Shenfield GM. Failure to weigh patients in hospital: A medication safety risk. Intern Med J [Internet]. 2007 Sep [cited 2021 May 17];37(9):647–50. Available from: https://pubmed.ncbi.nlm.nih.gov/17714205/

7. Spicer K, Gibson P, Bloe C, Cross SJ, Leslie SJ. Weight assessment in cardiac patients: Implications for prescription of low molecular weight heparin. Postgrad Med J [Internet]. 2009 Mar [cited 2021 May 17];85(1001):124–7. Available from: https://pubmed.ncbi.nlm.nih.gov/19351637/

8. Hendershot KM, Robinson L, Roland J, Vaziri K, Rizzo AG, Fakhry SM. Estimated Height, Weight, and Body Mass Index: Implications for Research and Patient Safety. J Am Coll Surg [Internet]. 2006 Dec [cited 2021 May

17];203(6):887–93. Available from: https://pubmed.ncbi.nlm.nih.gov/17116557/

9. Clarkson DM. Patient weighing: standardisation and measurement. Nurs Stand. 2012 Mar;26(29):33–7.

10. Chumlea et al. Prediction of body weight for the nonambulatory elderly from anthropometry. J Am Diet Assoc. 1988;(88):564–8.

11. Barceló M, Torres O, Mascaró J, Francia E, Cardona D, Ruiz D. Assessing nutritional status in the elderly; evaluation of Chumlea's equations for weight. Nutr Hosp. 2013;28(2):314–8.

12. MW L, M G, C H, M H, U Z, M S, et al. Anthropometric approximation of body weight in unresponsive stroke patients. J Neurol Neurosurg Psychiatry [Internet]. 2007 Dec [cited 2021 Jul 22];78(12):1331–6. Available from: https://pubmed.ncbi.nlm.nih.gov/17494978/

13. Crandall CS, Gardner S, Braude DA. Estimation of Total Body Weight in Obese Patients. Air Med J. 2009 May 1;28(3):139–45.

14. Melo APF, de Salles RK, Vieira FGK, Ferreira MG. Métodos de estimativa de peso corporal e altura em adultos hospitalizados: Uma análise comparativa. Rev Bras Cineantropometria e Desempenho Hum. 2014;16(4):475–84.

15. Díaz de León González E, Tamez Pérez HE, Hermosillo HG. Weight estimation in Mexican elderly outpatients from anthropometric measures from the SABE study. Nutr Hosp. 2011;26(5):1067–72.

16. Geurden B, Franck E, Van Looy L, Weyler J, Ysebaert D. Self-reported body weight and height on admission to hospital: A reliable method in multi-professional evidence-based nutritional care? Int J Nurs Pract. 2012 Oct;18(5):509–17.

17. Darnis S, Fareau N, Corallo CE, Poole S, Dooley MJ, Cheng AC. Estimation of body weight in hospitalized patients. QJM [Internet]. 2012 Aug [cited 2021 Jul 27];105(8):769–74. Available from: https://pubmed.ncbi.nlm.nih.gov/22491655/

18. Leal LP, Mognhol MS, Silva NMF, Petarli GB, Nunes PMF, Guandalini VR. CONCORDANCE BETWEEN EQUATIONS FOR BODY WEIGHT ESTIMATION AND THEIR USE IN DETERMINING BODY MASS INDEX IN HOSPITALIZED MEN AND WOMEN. DEMETRA Aliment Nutr Saúde. 2017;12(1).

19. Opdam MH, Koekkoek KWAC, Boeije T, Mullaart N, Van Zanten ARH, Bellou A. Mid-arm circumference method is invalid to estimate the body weight of elderly Emergency Department patients in the Netherlands. Med (United States) [Internet]. 2019 Aug 1 [cited 2021 Jul 27];98(32). Available from: https://pubmed.ncbi.nlm.nih.gov/31393379/

20. Melo APF, de Salles RK, Vieira FGK, Ferreira MG. Métodos de estimativa de peso corporal e altura em adultos hospitalizados: Uma análise comparativa. Rev Bras Cineantropometria e Desempenho Hum [Internet]. 2014 [cited 2021 May 14];16(4):475–84. Available from: http://dx.doi.org/10.5007/1980-0037.2014v16n4p475

21. Bernal-Orozco MF, Vizmanos B, Hunot C, Flores-Castro M, Leal-Mora D, Cells A, et al. Equation to estimate body weight in elderly Mexican women using anthropometric measurements. Nutr Hosp [Internet]. 2010 [cited 2021 May 14];25(4):648–55. Available from: http://www.redalyc.org/articulo.oa?id=309226761018

22. Peso A, Alexandre E, Santos D, Camargo RN, Paulo AZ. Comparative analysis of equations for estimating weight and height for hospitalized patients. Vol. 27, Rev Bras Nutr Clin. 2012.

23. Guerra RS, Sousa-Santos AR, Sousa AS, Valdiviesso R, Afonso C, Moreira P, et al. Prediction equations for estimating body weight in older adults. J Hum Nutr Diet [Internet]. 2021 [cited 2021 Aug 13]; Available from: https://pubmed.ncbi.nlm.nih.gov/33966329/

24. Despacho 6634/2018, 2018-07-06 - DRE [Internet]. 2018 [cited 2021 Aug 18]. Available from: https://dre.pt/home/-/dre/115652170/details/2/maximized?print_preview=print-preview

25. Melo APF, de Salles RK, Vieira FGK, Ferreira MG. Métodos de estimativa de peso corporal e altura em adultos hospitalizados: Uma análise comparativa. Rev Bras Cineantropometria e Desempenho Hum [Internet]. 2014 [cited 2021 Aug 13];16(4):475–84. Available from: http://www.scielo.br/j/rbcdh/a/RmYJqCqFJ4YSBZVJMVxYBGt/?lang=pt

26. Flentje KM, Knight CL, Stromfeldt I, Chakrabarti A, Friedman ND. Recording patient bodyweight in hospitals: are we doing well enough? Intern Med J [Internet]. 2018 Feb 1 [cited 2021 Aug 13];48(2):124–8. Available from: https://pubmed.ncbi.nlm.nih.gov/28589617/

27. Matos L, Teixeira MA, Henriques A, Tavares MM, Álvares L, Antunes A, et al. Menções sobre o estado nutricional nos registos clínicos de doentes hospitalizados. Acta Med Port. 2007;20(6):503–10.