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| ORIGINAL

Agreement of body weight of older adults measured on digital chair scale and mechanical platform scale

Concordância do peso corporal de idosos aferido em cadeira balança digital e em balança plataforma mecânica

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ABSTRACT

Objective

The aim of the study was to evaluate the agreement between the weight of older adults measured on a chair scale and a platform scale.

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Methods

This is a cross-sectional study. We evaluated 131 older adults (≥60 years old), walk-in patients, admitted to a university hospital. Weight was measured on a digital chair scale model MS5811 (Charder® brand) and after on a mechanical platform scale (Filizola® brand). For the agreement analysis, the intraclass correlation coefficient and the Bland-Altman plot were used.

Results

Most of the sample consisted of males individuals (57.3%; n= 75). The average age was 70.47±7.59 years (60-96 years old). Measured by both methods, weight showed normal distribution. The average weight measured was 67.99±14.03 kg on the chair scale and 68.04±14.02 kg on the platform scale. The intraclass correlation coefficient of weight measured by the two methods was 1.00 (IC95%=1.00-1.00; p<0.001). In the Bland-Altman plot, the mean bias for the weight measured on the chair scale and the platform scale was 0.049 (IC95%=-0.011 to 0.110; p=0.1084).

Conclusion

The agreement between the weight measured on a chair scale and on a platform scale was almost excellent. Thus, the chair scale can be used as an alternative method of measuring weight, especially in the older adults with postural instability, mobility restrictions or immobility syndrome.

Keywords: Aged. Anthropometry. Body weight. Hospitalization. Nutrition assessment.

RESUMO

Objetivo

O objetivo deste estudo foi avaliar a concordância entre o peso de idosos aferido em cadeira balança e em balança plataforma.

Métodos

Trata-se de um estudo transversal. Foram avaliados 131 idosos (≥60 anos), deambulantes, internados em um hospital universitário. O peso foi aferido em cadeira balança digital modelo MS5811 (marca Charder®) e, logo após, em balança plataforma mecânica (marca Filizola®). Para a análise de concordância, foram utilizados o coeficiente de correlação intraclasse e o gráfico de Bland-Altman.

Resultados

A maioria da amostra era constituída por indivíduos do sexo masculino (57,3%; n=75). A média de idade foi de 70,47±7,59 anos (60-96 anos). O peso, aferido pelos dois métodos, apresentou distribuição normal. A média do peso aferido na balança plataforma foi de 68,04±14,02kg e, na cadeira balança, de 67,99±14,03kg. O coeficiente de correlação intraclasse do peso aferido pelos dois métodos foi 1,00 (IC95%=1,00-1,00; p<0,001). No gráfico de Bland-Altman, o viés médio para o peso aferido na cadeira balança e na balança plataforma foi de 0,049 (IC95%=-0,011 a 0,110; p=0,1084).

Conclusão

Observou-se concordância quase perfeita entre o peso aferido em cadeira balança e em balança plataforma. Assim, a cadeira balança pode ser utilizada como um método alternativo de aferição do peso, especialmente nos idosos com instabilidade postural, restrição de mobilidade ou com síndrome da imobilidade.

Palavras-chave: *Idoso. Antropometria. Peso corporal. Hospitalização. Avaliação nutricional.*

INTRODUCTION

Anthropometric measurements are parameters used to evaluate the nutritional status of older adults. Anthropometry is indicated as a feasible, inexpensive method and as an effective predictor of morbidity and mortality. Anthropometric measurements are useful for both diagnosing and monitoring of diseases [1]. Nutritional assessment is part of the geriatric assessment, and malnutrition occurs often among older individuals [2]. Aging is associated with various physiological changes, which may have significant implications on the nutritional status of older individuals [3].

The nutritional assessment of older individuals presents particular characteristics that differentiate it from the assessment of individuals in other age groups. One way to evaluate and monitor the nutritional status of older individuals is through anthropometric measurements (weight, height, body mass index, and calf circumference). Another way is by controlling unintentional weight loss in the last 12 months ("Did you experience unintentional weight loss of at least 4.5kg or 5% of your body weight in the last year?"). The *Ministério da Saúde do Brasil* (MS, Ministry of Health of Brazil) recommends the application of both methods in primary healthcare in the Health Booklet for Older Adults [1]. Weight loss is a major independent risk factor for mortality in older inpatients [4]. Body weight is also an anthropometric measurement used to assess and manage older inpatients [5]. In the Brazilian Consensus on Nutrition and Dysphagia in Older Inpatients [6], weight is presented as an anthropometric indicator for the nutritional assessment of older patients, and it is also a component of screening and nutritional assessment instruments, such as the Mini Nutritional Assessment (MNA®) [2,6]. Calculating the medication dosage, fluid balance, dialysate flow rate, and nutritional needs are examples of inpatient clinical care practices that take body weight into consideration [7].

Certain aspects relative to the equipment and assessor are necessary to measure weight properly. The equipment must be in perfect working order (maintenance and calibration) and position (on a smooth and leveled surface). The evaluators must be well-trained, and they must routinely check the equipment prior to use, follow the specific recommendations for measuring weight, and consider the individual's clinical conditions when selecting the most appropriate equipment for measurement [8,9].

Despite the recommendations for weight measurement, the *Inquérito Brasileiro de Avaliação Nutricional Hospitalar* (IBRANUTRI, Brazilian Survey of Hospital Nutritional Assessment), which was conducted in 25 general hospitals (with at least 200 beds) and that evaluated 4,000 patients, found the following: (1) scales were positioned up to 50m from the patients' beds, (2) there was no record of the nutritional status (3) and there was no record of the body weight in most of the medical records upon admission of patients (in 75%, 81.2% and 84.9% of the cases, respectively) [10]. Additionally, weight measurement may be hindered by technical difficulties (such as mobility difficulties-displacement of the older patient on the scales and difficulties in maintaining balance or standing-postural instability) [11]. In these situations, as well as for critically ill (admitted to intensive care units [ICUs]) or bedridden patients (with immobility syndrome), the task of measuring weight is hindered and cannot be performed conventionally by way of platform scales (mechanical or digital), thus posing a challenge for healthcare professionals [12]. From this perspective, there are alternative methods of estimating weight through equations (such as those developed by Rosa); however, there are also alternative methods of measuring weight (such as using the bed scale) [11,13,14]. A scale with features that arouses interest for application in clinical practice is the chair scale since it is easy to handle (it is portable and digital) and store (its volume is similar to that of a wheelchair). However, national and international studies which incorporate the use of the chair scale are scarce and do not address this equipment's accuracy.

Therefore, this study aims to evaluate the agreement between the weight of older adults measured on a digital chair scale and a mechanical platform scale.

METHODS

This is a cross-sectional study which used a convenience sample taken from the database of the project *Desenvolvimento e Validação de Equações para Estimativa de Altura e Peso Corporal para Idosos* (Development and Validation of Equations for Estimating Height and Body Weight for Older Adults). All the participants in this study met the following inclusion criteria: age 60 years or older, walk-in patients, inpatients in the geriatric inpatient unit or inpatient unit of the *Sistema Único de Saúde* (SUS, Unified Health System) of a university hospital in the southern region of Brazil (*Hospital São Lucas* of the *Pontifícia Universidade Católica do Rio Grande do Sul* – PUCRS) in the period between July 1, 2014 and January 31, 2015. Individuals who presented with fluid retention (edema and/or ascites), lipodystrophy, amputated and/or immobilized limbs, and difficulties in positioning themselves on the platform scale were excluded. For individuals who had been hospitalized more than once during the study period, only their first assessment was considered in this study.

The following variables were investigated: the age, sex, weight measured on the chair scale, and weight measured on the platform scale.

Weight measured on the digital chair scale (kg): A Charder® (Taichung City, Taiwan) Medical Scale MS5811 digital chair scale with factory calibration and a maximum capacity of 200kg (with a graduation of 100g for weight between 0 and 100kg and 200g for weight between 100 and 200kg) and an accuracy of ±200g was used. Based on the manual's recommendations, the chair scale does not require routine maintenance; however, it should be calibrated depending on the level of use and its state of repair. Since the chair was new and used only in the present study, there was no need for maintenance during the data collection period. The equipment was positioned on a flat, hard surface. The individuals wore light clothing and were barefoot when they were seated in the chair that was locked in place. Their arms and feet were supported by the arm and foot rests of the chair scale, respectively, in accordance with the guidelines of the equipment manual [15].

Weight measured by the mechanical platform scale (kg): Filizola® (*São Paulo*, Brazil) mechanical scales with a maximum capacity of 200kg and a precision of 0.1kg, which were available at the sites where data was collected, were used in the study. The scales were calibrated by a service authorized by the I*nstituto Nacional de Metrologia, Qualidade e Tecnologia* (INMETRO, National Institute of Metrology, Standardization, and Industrial Quality) prior to data collection. Subsequently, the recommendations for the maintenance/calibration routine were also followed. The researchers verified that the pointer and the zero point were horizontally aligned prior to each measurement. If not, the researchers calibrated the equipment by rotating the adjustment knob until the pointer and zero point were leveled, at which point, the scale was locked, and only then did the individuals stood the scale [8]. The individuals stood on the platform of the scale, evenly distributing their weight on their feet. They were all barefoot and wore light clothing when they were being weighed [9].

Weight was measured by two researchers, whereas each individual was assessed by only one researcher. One of the researchers had level I certification by the International Society for the Advancement of Kinanthropometry (ISAK), and he had trained the other assessor [9]. The training had a duration of approximately 3 hours and included theoretical and practical content for the purpose of standardizing the technique and minimizing measurement errors (intra- and inter-assessor differences). As for the order of the measurements, weight was first measured on the chair scale and then on the platform scale.

Data were entered into an Excel spreadsheet and analyzed using the SPSS version 21 program. Continuous data were tested for normality using the Kolmogorov-Smirnov test. The results were presented as mean, standard deviation, and the maximum and minimum range. The Intraclass Correlation Coefficient (ICC) was calculated to assess the agreement between the weights measured by the chair scale and the platform scale. The ICC was classified by the Landis and Koch scale [16] as having poor (<0.00), slight (0.00-0.20), fair (0.21-0.40), moderate (0.41-0.60), substantial (0.61-0.80), and almost perfect (0.81-1.00) agreement. The Bland and Altman plot [17] was also used to verify the agreement between the two methods. We considered a deviation of up to 5% within the 95% limits of agreement (accepted bias within 1.96 x standard deviation) to be clinically acceptable [17]. The methods are thought to have good agreement if bias is near zero, and it is not statistically significant [18,19].

Moreover, given the agreement analysis, the sample size was estimated by evaluating the precision of the bias and the limits of agreement. According to Bland and Altman [17], with a sample size of 100, it is possible to estimate the values (bias and limits) with an approximate 95% Confidence Interval (CI) of ±0.34 standard deviation.

The primary study (previously mentioned) was approved by the Research Ethics Committee of the Pontifical Catholic University of *Rio Grande do Sul* (CAAE 26879814.4.0000.5336, approval No. 643.175 and No. 790.495). The researchers stated that they had followed the recommendations of Resolution 466/12 of the National Health Council of the Ministry of Health of Brazil [20]. All participants, or their legal representatives, signed the informed consent form.

RESULTS

A total of 131 older adults were evaluated, including 75 men (57.3%) and 56 women (42.7%) with a mean age of 70.47±7.59 years (minimum of 60 years and maximum of 96 years).

The mean weight measured on the platform scale was 68.04±14.02kg (range between 40.0 and 111.9kg). The mean weight measured on the chair scale was 67.99±14.03 kg (range between 40.0 and 112.8kg). Both variables presented normal distribution.

The ICC of the weight measured on the chair scale relative to the weight measured on the platform scale was 1.00 (95%CI= 1.00-1.00; $p<0.001$), which demonstrated an almost perfect agreement.

Figure 1 illustrates the Bland-Altman plot. The mean bias for the weight measured by the chair scale and platform scale was 0.049 (95%CI=-0.011-0.110; $p=0.1084$), which indicated a good agreement between the methods.

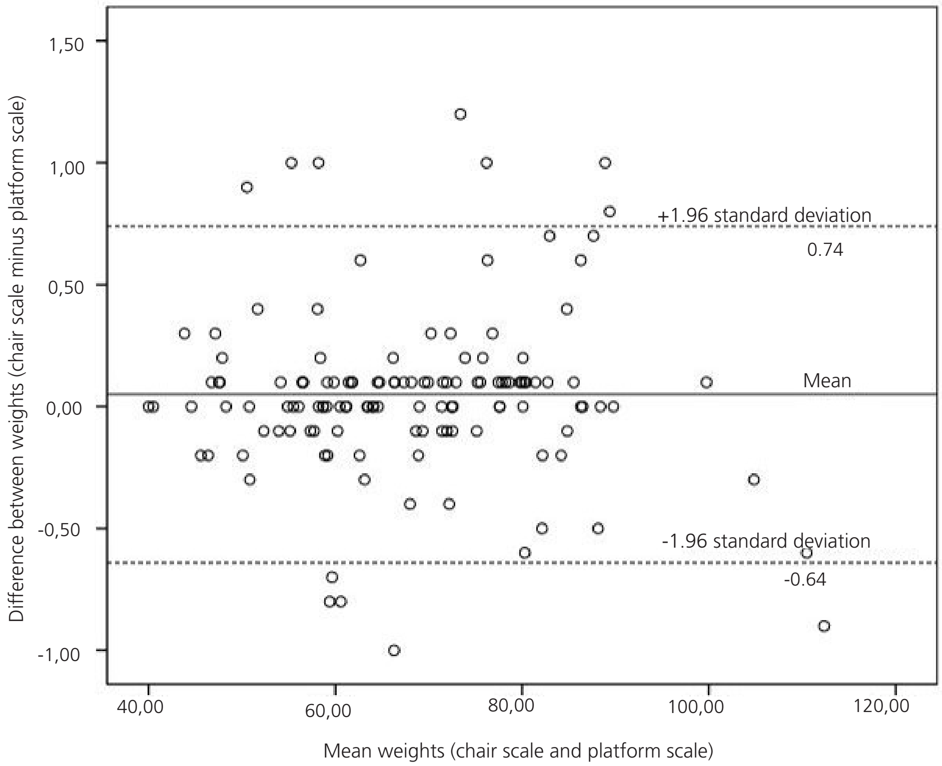

Figure 1 – The Bland-Altman plot of the weight of older adults measured by a digital chair scale and mechanical platform scale.

The results thus show that the methods used herein do not differ in their capacity to measure weight.

DISCUSSION

In this study, an almost perfect agreement was found between the values of weight measured by the chair scale and platform scale.

The literature on weight measured by nonconventional equipment (scales other than platform scales) is scarce. This is also the case for the use of chair scales. In a search through the MEDLINE (via PubMed) and EMBASE databases with the index terms "chair scale" OR "chair-scale," we identified three articles that contemplated the use of chair scales [21-23].

In 1957, Silverman and Ikefugi [21] published a clinical note in the *Journal of the American Medical Association* describing the development of a portable chair scale. The study tested the equipment with 20 inpatients. The authors concluded that the equipment was suitable for weighing patients who had difficulty standing and that measurement was feasible in hospital routines, particularly because the equipment was easy to handle. It consisted of a wooden chair placed on top of a platform scale, which was one of the first pieces of equipment to measure body weight with patients in the sitting position [21].

A study by Owen and Garg [22] in 1994, motivated by the high prevalence of spinal issues among nurses, analyzed three methods of weighing older adults: (1) by a chair attached to a mechanical platform scale (the patient was lifted manually by two nurses from a wheelchair and transferred to the chair attached to the platform scale, the weight was measured, and subsequently the patient was placed back in the wheelchair); (2) by a scale with a wheelchair ramp and a platform for covering the scale (the wheelchair was pushed onto the ramp of the scale); and (3) by a scale attached to a mechanical hoist (the patient was weighed after being lifted by the hoist). Six nursing students served as both the "nurses" (who weighed the patients) and the "patients." In the group of students who acted as the "nurses," the greatest overload was observed in the technique used to lift the patient from the chair (the shoulders were most often reported as the body part supporting a great overload), followed by the scale attached to a mechanical hoist, and subsequently by the method of pushing the wheelchair onto the ramp of the scale. As for the time spent weighing the patients, the technique of pushing the wheelchair took the least amount of time, while the method of lifting the patient with a hoist took the most. The "patients" perceived that sitting in the wheelchair was comfortable and safe, followed by being lifted via the hoist, and finally by being lifted by hand [22].

A study conducted by Eastwood [23] in the cardiac care unit and medical and surgical intensive care unit of a hospital in Australia aimed at investigating the change in body weight in adult patients undergoing cardiac surgery and evaluating the precision of conventional methods for charting the recorded fluid balance levels so as to reflect this change in body weight. Thirty-two patients were included in the study. An HV-CS (A&D Mercury Pty Ltd, Victoria, Australia) ergonomically-designed digital chair scale brand was used to weigh the patients. The researchers observed that only 9.75% of the patients met the criteria for accurately recorded fluid balance levels and that 25% of the patients presented an inverse relation between recorded fluid balance levels and changes in body weight [23]. The equipment used in this study was most closely related to the equipment applied in our study.

Therefore, as demonstrated, studies incorporating chair scales are scarce. Furthermore, they were developed in the United States, the United Kingdom, and Australia, and they did not present the same objective as the one presented herein [21-23].

The strength of this study hence, lies in three aspects: (1) it is unprecedented as it is the first study to verify the agreement of the weight measured by two different scales, one of which is a chair scale; (2) the individuals were weighed at the same moment, thus avoiding variations in weight, such as those owing to the hydration status; and (3) a nutritionist certified by ISAK took measurements and trained the team. However, the study also presents limitations, one of which is its sample size. At the same time, the number of participants included in the study meets the sample size suggested by Bland and Altman [17].

To obtain the body weight of bedridden patients or patients with movement restrictions that prevent them from positioning themselves onto platform scales, the healthcare professional must seek alternatives, such as chair scales and bed scales [14]. The easiest, least expensive way to measure their weight is to estimate their body weight by using equations; however, these equations are not always accurate [13]. An instrument that can accurately measure weight contributes to reliable decision-making in clinical practice is available [24]. The body weight value directly influences medication dosages, caloric values, and dietary nutritional values, among other procedures performed in hospitals, outpatient clinics, or even at home [5]. It is also a good predictor of disease and mortality [1].

A study conducted in Australia evaluated the theoretical advantages and disadvantages of six methods of weighing ICU patients: (1) "mid-arm-circumference", (2) "bed scale" (Mercury bed scale - A&D, Kensington VIC, Australia), (3) "bed scale" (Hill-Rom bed with an integrated scale - Medicraft, Marrickville NSW, Australia), (4) "digital standing scale" (Soehnle, Castle Hill NSW, Australia), (5) "ceiling hoist scale" (GULDMANN ceiling hoist scale - HLS Ringwood, VIC, Australia), and (6) "chair scale" (A&D, Kensington VIC, Australia). The researchers designed an assessment consisting of 12 items (the setup time, equipment availability, equipment costs, the number of people needed for the technique, the level of lumbar strain, the amount of storage space, requirements for ongoing maintenance, aspects of the patient's safety, the method's accurate prediction, the need for training, the percentage of patients who could be weighed by the method, and the risk of infection related to disconnection of invasive catheter lines due to the need to transport the patient). The information used to complete the assessment was obtained from three sources: scientific events in the intensive care area (conferences), the internet, and devices available in the hospital. The chair scale method presented the worst score (29 points), particularly because it requires moving the patient from the bed to the chair scale, and this procedure involves risks when managing ICU patients. The method employing the mid-arm-circumference obtained the best score (13 points.) However, the positive aspects of the "chair scale" were its accuracy (same score as that of the "bed scales" and the "ceiling hoist scale" and a better score than that of the "digital standing scale" and "mid-arm-circumference") and cost (the "chair scale" had the second lowest cost, second only to the "digital standing scale") [12].

Measuring equipment regularly exposed to routine use requires preventive maintenance to ensure its calibration and minimize systematic errors in weight measurement and in the management of different clinical conditions. Routine certification of this equipment seems to be a simple measure that is easy to adopt and that directly benefits the entire population. The value of the body weight measured at the moment can be affected by the application of a bad technique, uncalibrated equipment, or equipment without validation for this purpose. The calibration of equipment is regulated by INMETRO Ordinance no. 236 of December 22nd, 1994 [25]. The international standard for the body weight measurement technique is established by ISAK [9]. To ensure proper measurement of body weight relative to instrument calibration, a verification technique and validated equipment for this purpose enables precise and accurate information, thus supporting the appropriate clinical management of patients [24].

Therefore, we emphasize that the method to measure body weight depends on the equipment's precision, accuracy, and cost and the physical conditions of the professional taking the measurements and patient (such as the general status, mobility, and postural stability). The patient's safety is a fundamental element in this process.

Despite the scarce studies that used and analyzed the precision of the chair scale, the results of this study demonstrate the potential of this equipment's application in clinical practice.

CONCLUSION

The degree of agreement found between the methods suggests that the chair scale can be used in clinical practice to measure body weight. Therefore, the digital chair scale can be a useful method, particularly in situations where patients present physical limitations for measurement, such as difficulties in standing on the scale, postural instability, or a critical illness or immobility syndrome. For accurate weight measurement however, it is important to consider factors related to the equipment, assessor, and patient accordingly.

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CONTRIBUTORS

MLF ANNES analyzed and interpreted the data, prepared the first draft of the manuscript, critically reviewed the manuscript, and approved the final draft of the manuscript. FB TABAJARA performed data collection and data entry, prepared the first draft of the manuscript, critically reviewed the manuscript, and approved the final draft of the manuscript. RD ROSA conceived and designed the study, applied the methodology, collected data, supervised data collection, critically reviewed the manuscript, and approved the final draft of the manuscript. R MATTIELLO analyzed and interpreted the data, applied the methodology, critically reviewed the manuscript, and approved the final draft of the manuscript. ALS Alves applied the methodology, prepared the first draft of the manuscript, critically reviewed the manuscript, and approved the final draft of the manuscript. CHA SCHWANKE conceived and designed the study, supervised the study, performed data curation, critically reviewed the manuscript, and approved the final draft of the manuscript.

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