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Validation of predictive equations for weight and height using a metric tape
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Abstract

Weight and height measurements are important data for the evaluation of nutritional status but some situations prevent the execution of these measurements in the standard manner, using special equipment or an estimate by predictive equations. Predictive equations of height and weight requiring only a metric tape as an instrument have been recently developed.

Objective: To validate three predictive equations for weight and two for height by Rabito and evaluating their agreement with the equations proposed by Chumlea.

Methods: The following data were collected: sex, age and anthropometric measurements, ie, weight (kg), height (m), subscapular skinfold (mm), calf (cm), arm (cm) and abdominal (cm) circumferences, arm length (cm), and half span (cm). Data were analyzed statistically using the Lin coefficient to test the agreement between the equations and the St. Laurent coefficient to compare the estimated weight and height values with real values.

Results: 100 adults (age 48 ± 18 years) admitted to the University Hospital (HCFMRP/USP) were evaluated. Equations I: W(kg) = 0.5030 (AC) + 0.5634 (AbC) +1.3180 (CC) +0.0339 (SSSF) – 43.1560 and II: W (kg) = 0.4808 (AC) + 0.5646 (AbC) +1.3160 (CC) – 42.2450 showed the highest coefficients of agreement for weight and equations IV and V showed the highest coefficients of agreement for height. The St. Laurent coefficient indicated that equations III and V were valid for weight and height, respectively.

Conclusion: Among the validated equations, the number III W (kg) = 0.5759 (AC) + 0.5263 (AbC) +1.2452 (CC) – 4.8689 (S) – 32.9241 and VH (m) = 63,525 -3,237(S) – 0,06904 (A) + 1,293 (HS) are recommended for height or weight because of their easy use for hospitalized patients and the equations be validated in other situations.

Key words: Anthropometry. Predictive equations. Weight. Height. Hospitalized patients.

Validation of predictive equations for weight and height using a metric tape

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Resumen

Las medidas de peso y talla son datos importantes para la evaluación del estado nutricional y también para el planeamiento de terapias nutricionales y medicamentosas. Entretanto, algunas situaciones imposibilitan la realización de estas medidas de forma convencional. En estos casos son necesarios equipamientos especiales o la estimativa por medio de ecuaciones predictivas. Recientemente fueran desarrolladas ecuaciones predictivas de peso y talla, que requieren como instrumento la cinta métrica.

Objetivo: Validar tres ecuaciones predictivas para el peso y dos para la talla, evaluando la concordancia de estas con las ecuaciones propuestas por Chumlea.

Métodos: Los datos recogidos fueran de sexo, edad, y medidas antropométricas como peso (kg); talla (m); pliegue cutáneo sub-escapular (mm); circunferencia de la pantorrilla (cm), del brazo (cm) y del abdomen (cm); longitud del brazo (cm) y media envergadura (cm). La evaluación estadística fue realizada utilizando el coeficiente de Lin, para evaluar la concordancia entre las ecuaciones, y el coeficiente St. Laurent, para comparar los valores estimados del peso y talla con los valores reales.

Resultados: Fueron evaluados 100 individuos (de los cuales 52% son del sexo femenino, internados en el Hospital de Clínicas (HCFMRP-USP). Las ecuaciones que presentaron mayores coeficientes de concordancia fueron I y II, para el peso y el IV y V para talla. Lo coeficiente de St. Laurent ha indicado que las ecuaciones III y V presentan validez para peso y talla, respectivamente.

Conclusión: Las ecuaciones III y V, validadas en este estudio, son recomendables por la facilidad de utilización.

Introduction

The monitoring of the nutritional status of hospitalized patients may be defined as a process based on diagnostic procedure that will determine the presence of tissue changes and/or nutrient depletion. The evaluation of patients submitted to long periods of hospitalization suggests an increased risk of nutritional complications. The risk of malnutrition in the elderly, specially under nutrition which is a common problem among elderly people living at home and during hospitalizations, condition that is closely related to the increasing of morbidity, mortality and costs.

Although most hospital diets provide sufficient energy and nutrients, previous studies examining food consumption in hospitalized patients showed mean daily energy and protein intakes in general patients failing to meet the Estimated Average Requirements—EAR.

Prevalence of hyponutrition in hospitalized patients is very high and it has been shown to be an important prognostic factor. Most of admitted patients depend on hospital food to cover their nutritional demands being important to assess the factors influencing their intake, which may be modified in order to improve it and prevent the consequences of inadequate feeding.

Body weight is extensively used as an indicator of nutrition status. Several studies correlate anthropometric characteristics such as weight with the incidence of certain types of chronic diseases. However, there are some situations in which these measurements cannot be made by standard methods, as is the case for bedridden patients and patients with difficulty in walking. Prevalence of hyponutrition in hospitalized patients is very high and it has been shown to be an important prognostic factor. Most of admitted patients depend on hospital food to cover their nutritional demands being important to assess the factors influencing their intake, which may be modified in order to improve it and prevent the consequences of inadequate feeding.

The nutrition in hospital influenced the body weight of hospitalized patients. Height is also an important element of anthropometric evaluation that may be difficult to determine using direct standard methods. In some cases, height measurements on a patient lying in bed using a metric tape can be adequate for hospitalized patients in a coma, critically ill or unable to move and the lean body weight has been recommended for scaling drug doses.

In view of these difficulties, several studies have been carried out to establish equations for the estimate of weight and height of hospitalized patients belonging to specific populations. These studies use other anthropometric measurements which require low cost equipment. The major problem is to adapt these equations according to the validity and applicability criteria used for each ethnic group. On this basis, it is imperative to validate these equations using a sample belonging to the same population, in addition to comparing them to similar equations based on the results of different studies.

Thus, the objective of the present study was to validate equations, in adults hospitalized patients, recently developed for the estimate of weight and height by Rabito et al. and to compare them to equations already described in the by Chumlea et al. in order to contribute to the process of nutritional evaluation of hospitalized Brazilian patients.

Methods

The study was conducted on the wards of the University Hospital, Faculty of Medicine of Ribeirão Preto, University of São Paulo, and was approved by the Ethics Committee of the Hospital. All patients or participating gave written informed consent. The inclusion criterion was patients able to walk, whereas patients with amputated limbs or immobilized, pregnant women and puerperae, patients with edema and/or ascites, and patients receiving intravenous hydration were excluded.

The measurements were made on 100 patients of both sexes older than 18 years after an overnight fast. The measurements were made on the right side in triplicate by trained professionals and the mean of the values obtained was calculated, being accepted the measures with variation lower that 5%. The following measurements were obtained: height (H, cm), weight (W, kg) with a stadiometer and a Filizola platform scale with 0.5 cm and 100 g divisions, respectively; knee height (KH, cm), using a pediatric stadiometer; arm length (AL, cm), calf circumference (CC, cm), arm circumference (AC, cm), abdominal circumference (AbC, cm), and half-span (HS, cm) measured with an non-extensible metric tape with 0.1 cm divisions; skinfolds (mm) measured with a Lange caliper calibrated with a constant pressure of 10 g/mm²; bicipital, tricipital, suprailliac, and subscapular (SSSF) with 1.0 mm division. After these measurements were obtained, concordance coefficients were calculated with the estimates of weight and height described by Rabito et al. and as shown in table I. The equations described by Chumlea et al. were also used for comparison, as shown in table I.

In the statistical analysis, the agreement between the equations developed by different authors was determined by the Lin coefficient, a concordance measure similar to the well known kappa coefficient. However, the kappa coefficient is suitable for the analysis of agreement between qualitative measurements, whereas the Lin coefficient is appropriate for measurements of a continuous nature. The absolute value of this measure varies between 0 and 1, and a high coefficient indicates that the respective equations will most likely equivalents. The measurements obtained by the equation by Rabito et al. to be validated were compared to the real weight and height values using the St Laurent coeffi-
cient, which is an extension of the Lin coefficient based on the assumption that one of the measurements in question is the gold standard or a measurement not subjected to measurement error. A high St Laurent coefficient indicates that the values from the equation under study are near to real weight and height values. Lin and St Laurent agreement coefficients were calculated with their 95% confidence intervals (95% CI).

Results

A total of 100 patients, 52% of them females, were chosen at random in the Hospital ambulatory and evaluated. Mean age was 48 ± 18 years, weight 66 ± 16.5 kg, height 162 ± 10.4 cm, and body mass index 25 ± 5.1 kg/m². The results obtained regarding the agreement of the equations for weight and height estimate are listed in table II. High Lin coefficients indicated greater agreement between the measurements obtained by equations I and II. The results presented in table II indicate that there was greater agreement between the height estimates obtained by equations IV and V.

The estimates obtained with the equations were compared to real weight and height values using the St. Laurent coefficient with a 95% confidence interval, presented in table III. Figures 1 and 2 indicate that the equations that presented validity were equations III and V of Rabito et al., with a 95% confidence interval (95% CI).

Discussion

On the basis of the results of the analysis it was possible to observe that the equations for weight estimate showed high concordance. However, equations I and II were those that presented the highest coefficient when compared to Chumlea, as showed in table I. Regarding the equations for height estimate, particularly outstanding was the high coefficient detected between equations IV and V, explained by the close proximity of the measurements estimated by them.

The St. Laurent coefficient is used to measure the extent to which these equations estimate values of variables such as weight and height comparable to real measures. The equation for weight estimate that presented the highest coefficient was the equation proposed by Chumlea, with a result statistically similar to that obtained for equation III. Thus, the choice of one of the two equations does not impair the weight estimate since the easy execution of the measurements is only one criterion for the choice of one of them, with

Table I

<table>
<thead>
<tr>
<th>Description of the equations compared in this study, by Rabito et al. and Chumlea et al. for weight and height based on anthropometric measurements</th>
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</thead>
<tbody>
<tr>
<td><strong>Equations for the prediction of weight (kg)</strong></td>
</tr>
</tbody>
</table>
| Equations by Rabito et al.6  
I 0.5030 (AC) + 0.5634 (AbC) + 1.3180 (CC) + 0.0339 (SSSF) - 43.1560  
II 0.4808 (AC) + 0.5646 (AbC) + 1.3160 (CC) - 42.2450  
III 0.5759 (AC) + 0.5263 (AbC) + 1.2452 (CC) - 3.8689 (S) - 32.9241 |
| Equations by Chumlea et al.11  
female (0.98 x AC) + (1.27 x CC) + (0.40 x SSSF) + (0.87 x KH) - 62.35  
males (1.73 x AC) + (0.98 x CC) + (0.37 x SSSF) + (1.16 x KH) - 81.69 |
| **Equations for height (cm)**                                                                                     |
| Equations by Rabito et al.6  
IV females 58.045 - 2.965 (S) - 0.07309 (A) + 1.094 (HS)  
V females 63.525 - 2.237 (S) - 0.06904 (A) + 1.293 (HS) |
| Equations by Chumlea et al.12  
female 84.88 - 0.24 (A) + 1.83 (KH)  
males 64.19 - 0.40 (A) + 2.02 (KH) |

H = height (m), AC = arm circumference (cm), AbC = abdominal circumference (cm), SSSF = subscapular skinfold (mm), (W), S = sex (1 = male; 2 = female), A = age (years), AL = arm length (cm), HS = half-span (cm), CC = calf circumference (cm) e KH = Knee height (cm).

Table II

<table>
<thead>
<tr>
<th>Measures of concordance between equations that estimate the weight and height of individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weight Lin concordance coefficient 95% CI</strong></td>
</tr>
</tbody>
</table>
| Equations I x II 0.9990 (0.9992-0.9996)  
Equations I x III 0.9802 (0.9700-0.9869)  
Equations II x III 0.9824 (0.9736-0.9883)  
Equations I x Chumlea 0.8709 (0.8126-0.9120)  
Equations II x Chumlea 0.8723 (0.8151-0.9127)  
Equations III x Chumlea 0.9247 (0.8899-0.9488) |
| **Height Lin concordance coefficient 95% CI**                                               |
| Equations IV x V 0.9831 (0.9750-0.9886)  
Equations IV x Chumlea 0.7695 (0.6758-0.8387)  
Equation V x Chumlea 0.7763 (0.6849-0.8436) |

Table III

<table>
<thead>
<tr>
<th>Measures of validation for equations that estimate the weight and height of individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weight St. Laurent coefficient 95% CI</strong></td>
</tr>
</tbody>
</table>
| Equation I 0.8146 (0.7536-0.8658)  
Equation II 0.8156 (0.7510-0.8630)  
Equation III 0.8524 (0.7882-0.8965)  
Chumlea Equation 0.8745 (0.8210-0.9105) |
| **Height St. Laurent coefficient 95% CI**                                               |
| Equation IV 0.8103 (0.7572-0.8558)  
Equation V 0.8219 (0.7698-0.8612)  
Chumlea Equation 0.7110 (0.6189-0.8736) |
the data needed for equation III being easier to obtain. The measurements made by equation III\textsuperscript{10} require only a metric tape, whereas the equation reported in the literature\textsuperscript{15,16} requires a metric tape, an adipometer and a pediatric stadiometer. Another limitation of the equation for weight estimate proposed by Chumlea\textsuperscript{15,16} concerns bedridden individuals with immobilized lower limbs that do not permit leg flexion for the measurement of knee height.

Among the equations for the estimate of height, equation V\textsuperscript{10} presented better agreement with real height; however, this equation shows limitations when...
applied to individuals with immobilized upper limbs. This limitation is similar to that of the equation proposed in the literature regarding the lower limbs. Thus, the choice of estimate methods is related to the clinical situation and to the equipment available in an institution. Hernández et al. worked with estimated equations achieved a very good correlation with the real height. Thus, in those subjects in whom assessment of the real height is not possible by conventional means, it is possible to use height prediction equations from simple techniques and equipment accessible to the whole health care staff.25

A method extensively used in intensive care or emergency units is the visual estimate of patient weight. Several studies have confirmed that this visual estimate of weight and height in intensive care units is of low accuracy when compared to real values.26 Also, in cases of emergency care it is necessary to obtain patient weight and height values very close to the real ones since the dose of the drugs to be administered depends on these measurements and, if incorrectly applied, it may cause toxicity or may not have the expected therapeutic effects. A recent study27 stated that the weight and height reported by the patient when he arrives at an emergency unit are more accurate than those estimated visually by the health professionals themselves. However, some limitations should be considered, such as patients with alterations of mental status, with injury or trauma who are unable to inform about their weight when they are hospitalized.

In view of the above considerations, it is very important to implement rapid and effective methods requiring little manipulation of the patient in order to obtain better estimates of height and weight in situations in which these measurements are essential, eg, for the calculation of drug doses to be administered.

Conclusion

Among the equations validated in the present study, we recommend equations III and V, for the estimate of weight and height in hospitalized adults, respectively, since they are easier to use and their statistical significance is high for sample of individuals in Brazil, permitting the determination of these data in a simple and direct manner. The easiness of obtain these measures allows to the same validation or the creation of new equations in other situations or populations.

References