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Using alternative or direct anthropometric measurements to assess risk for malnutrition in nursing homes☆

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A B S T R A C T

Objective: The aim of this study was to use the Malnutrition Universal Screening Tool (MUST) to assess the applicability of alternative versus direct anthropometric measurements for evaluating the risk for malnutrition in older individuals living in nursing homes (NHs).
Methods: We conducted a cross-sectional survey in 67 NHs in Tuscany, Italy. We measured the weight, standing height (SH), knee height (KH), ulna length (UL), and middle-upper-arm circumference of 641 NH residents. Correlations between the different methods for calculating body mass index (BMI; using direct or alternative measurements) were evaluated by the intraclass correlation coefficient and the Bland-Altman method; agreement in the allocation of participants to the same risk category was assessed by squared weighted kappa statistic and indicators of internal relative validity.
Results: The intraclass correlation coefficient for BMI calculated using KH was 0.839 (0.815–0.861), whereas those calculated by UL were 0.890 (0.872–0.905). The limits of agreement were ±6.13 kg/m^2 using KH and ±4.66 kg/m^2 using UL. For BMI calculated using SH, 79.9% of the patients were at low risk, 8.1% at medium risk, and 12.2% at high risk for malnutrition. The agreement between this classification and that obtained using BMI calculated by alternative measurements was "fair-good."
Conclusion: When it is not possible to determine risk category by using SH, we suggest using the alternative measurements (primarily UL, due to its highest sensitivity) to predict the height and to compare these evaluations with those obtained by using middle-upper-arm-circumference to predict the BMI.

Introduction

Malnutrition in older individuals who are institutionalized is frequent and significantly affects both physical functioning and cognition, resulting in increased morbidity and mortality as well as representing either a direct or indirect cost to society [1–3].

The routine use of screening protocols for the early identification and consequent management of appropriate interventions is useful for preventing the risk for malnutrition, which allows for early interception of nutritional needs and provides improved clinical outcomes and reduced health care costs [4]. Many screening tools are available to assess malnutrition or the

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risk for malnutrition, and these differ depending on the setting, target population, or aims [5]. In particular, the Malnutrition Universal Screening Tool (MUST) has been developed for adults in all care settings. MUST is simple, quick to be applied, and has shown excellent reliability as well as a fair-good to excellent agreement regarding the detection of malnutrition compared with other tools [5–7]. MUST has been designed to detect protein–energy malnutrition and the risk for developing malnutrition using three evidence-based criteria, namely, body mass index (BMI), unintentional weight loss, and acute disease effects that produce or are likely to produce no nutritional intake for more than 5 d [6,8]. A score is assigned to each criteria, which are evaluated in three different steps. The total score, obtained by summation, allows the classification of the individual into a low-, medium-, or high-risk category of malnutrition [9]. If it is not possible to obtain the individual's height and weight by using a standard, direct method, then alternative measurements are used to either calculate or estimate BMI. Specifically, if it is not possible to measure standing height (SH), then it is possible to estimate it using measurements of other body segments (i.e., knee height [KH] and ulna length [UL]) in specific equations. Similarly, when it is not possible to obtain the individual's weight, BMI can be estimated using the middle upper arm circumference (MUAC) measurement [10–15]. The equations for estimating both height and BMI have been tested in many international studies, with different results depending on either the population included or the body segments considered [8,12,14–16]. To date, there are no studies aimed at examining how much the use of direct or alternative measurements influences the assessment of the risk for malnutrition in a frail population.

The purpose of this study was to assess the applicability, for public health purposes, of alternative versus direct anthropometric measurements for evaluating the risk for malnutrition, as detected by MUST, in older NH residents.

Materials and methods

Setting and study design

The study was part of the Monitoring the Quality of Care in Nursing Homes project financed by the Italian Ministry of Health, conducted between 2011 and 2012. The project enrolled 2801 individuals living in 67 NHs (~22% of all of the Tuscan NHs in 2011), whose directors voluntarily joined the study, excluding residents who joined day-care center programs.

Data were collected in a cross-sectional survey, conducted between January and March 2012, by 89 trained staff members of the NHs. Information to identify the risk for malnutrition (anthropometric measurements, unplanned weight loss in 3–6 mo, acute disease that produces or is likely to produce no nutritional intake for at least 5 d) was recorded on forms designed for optical reading.

The study was conducted according to the principles of the Helsinki Declaration and was approved by the Regional Committee for Bioethics (of Tuscany Region) and by the Ethics Committee of the Local Health Units of Siena, Firenze and Pisa.

Detection of anthropometric measures and assessment of risk for malnutrition

Whenever possible (i.e., when a scale and a stadiometer were available in the NH, when residents agreed to be measured and their health state was compatible with the detection of measurements using standardized methods [17] also described in the MUST explanatory booklet [9]), the following anthropometric measurements were collected: weight, height, KH, UL, and MUAC. All measurements were obtained according to the indications reported in the MUST report [9], through scales and stadiometers that were present in each NH. It is important to note that in Tuscany, the presence of any type of scale and of the stadiometer in an NH is not mandatory. Each ward also was equipped with an inelastic meter for the measurement of the body segments and the MUAC. Using the MUST equations [9], the KH and the UL were used for estimation of height, whereas the MUAC was used to estimate BMI range (<18.5, 18.5–20, or >20 kg/m^2). Weight and height (measured and/or estimated) were used to calculate BMI. Therefore, BMI was calculated by four different modes: one from SH, two from alternative measurements for estimating the height (KH, UL), and one in which BMI range was estimated by MUAC. Consequently, the step 1 score and the total score of the MUST have been calculated in a number of ways equal to the number of BMI values available for each resident (a maximum of four). The assignment of the malnutrition risk category (low, medium, high) to each individual was conducted following the instructions provided in the MUST report: low if the total score was 0, medium if the score was 1, high if the score was >1 [9].

Statistical analysis

Data were presented as mean and SD. The comparison between means across sex was performed by Student's two-tailed *t* test for independent data.

The correlation between the different methods (repeatability) to calculate BMI (calculated using either the SH or an estimated height) was evaluated using the intraclass correlation coefficient (ICC) [18] and the Bland-Altman method [19], as suggested previously [20,21]. With the Bland-Altman method, the differences between the values obtained from using two methods (the BMI calculated with SH, which is considered to be the reference, minus the BMI obtained using estimated height) and their mean values are plotted on a graph on the ordinate and the abscissa, respectively. Good agreement between two measurements (i.e., interchangeability of measurements) should result in a narrow scatter around the zero of the random differences between the methods in a direction that is parallel to the abscissa, which represents the mean values of both measurements. Because the distribution of the differences between the values obtained using the two methods was parametric, the limits of agreement were identified as the mean differences between the values obtained using the two methods plus or minus 1.96 SDs of the differences.

To take into account the ordinal nature of the MUST scale, the agreement in the allocation of the individuals into the same risk category of malnutrition (low, medium, high) was assessed by squared weighted kappa statistics and their bootstrapped 95% confidence interval (CI). Here, values between 0.400 and 0.750 indicated "fair-good" agreement, whereas higher values were an indicator of "excellent" agreement.

To describe the internal relative validity of MUST (i.e., the allocation into the same risk category using the different methods just reported), sensitivity, specificity [22], positive predictive value, and negative predictive value [23] were calculated with respect to the reference classification, namely that obtained using the BMI calculated by direct measurements of height and weight. Because either medium- or high-risk individuals are of public health concern and require the implementation of preventive and/or containment interventions, the high- and medium-risk categories were regrouped into a new group (medium/high-risk for malnutrition).

The analyses were performed using SPSS 19.0 and R. For each analysis, α-level = 0.05 was considered significant.

Results

The number of NHs included in the study was 67 with a total of 2801 residents. All individuals <64 y old (n = 194) were excluded from the analysis, according to the aim of the study. For most of the individuals, it was not possible to detect all the measurements due to 1) the absence of an appropriate scale, 2) specific conditions that have hindered the detection according to standard methods (i.e., kyphosis, bedridden patients, unable to stand upright, or cognitive impairment), or 3) lack of interest in participating in the study. For each of the 2801 residents, it was possible to detect at least one or two measurements (MUAC for the most).

Finally, we were able to obtain all of the measurements by the previously described methods for 641 residents (444 women, 197 men) aged >64 y, which represents 22.9% of the total number of individuals of the same age class enrolled in the study.

Women were older than men (84.59 ± 8.3 versus 79.9 ± 7.9 y; $P < 0.05$), and 25% of the women were >91 y and 25% of men were >85.5 y.

Table 1 shows a descriptive analysis of the weight, height, and BMI of the residents.

BMI values were not significantly different by sex, however, men were significantly ($P < 0.001$) heavier (71.4 ± 15.0 kg versus 62.1 ± 14.1 kg) and taller (measured height: 1.66 ± 0.08 m versus 1.55 ± 0.08 m; estimated using KH: 1.65 ± 0.09 m versus 1.54 ± 0.06 m; estimated using UL: 1.72 ± 0.06 m versus 1.61 ± 0.07 m) than women (data not shown in table).

Table 1
Weight, height, and BMI: descriptive analysis (N = 641)

	Weight (kg)	Height (m)			BMI (kg/m^2)		
		Standing	Predicted using knee height	Predicted using ulna length	Using the standing height	Using knee height to predict height	Using ulna length to predict height
Mean ± SD	64.9 ± 15.0	1.58 ± 0.09	1.57 ± 0.09	1.64 ± 0.08	25.8 ±5.3	26.2 ± 5.9	24.1 ± 5.2
Quartiles							
25	53.5	1.52	1.51	1.58	22.20	22.06	20.36
50	64.3	1.58	1.56	1.63	25.80	25.64	23.54
75	74.0	1.65	1.62	1.68	29.28	29.61	27.36

BMI, body mass index

ICC values were 0.839 (0.815–0.861) for BMI calculated using SH compared with BMI calculated using height estimated by KH, and 0.890 (0.872–0.905) when BMI was calculated using SH compared with using height estimated by UL (data not shown in table).

The limits of agreement (±1.96 SD) by the Bland-Altman method were ± 6.13 kg/m^2 for BMI when calculated using KH (mean difference: −0.38 kg/m^2) and ±4.66 kg/m^2 for BMI calculated using UL (mean difference: 1.80 kg/m^2) (Fig. 1).

When using SH to calculate BMI, 79.9% of the patients were at low risk for malnutrition, 8.1% were medium risk, and 12% were at high risk, according to the MUST (Table 2). The agreement between this classification and that obtained using BMI calculated both by the estimated height and MUAC was “excellent,” with higher values of kappa when BMI was calculated by estimated height compared with the agreement obtained using BMI estimated from MUAC. The agreement in classification by risk category did not vary, after stratifying either by sex or age, with the exception of having a “poor agreement” for men ages 65 to 84 y when using BMI estimated by SH and MUAC.

The proportion of individuals who were classified in the same way with respect to the reference classification (i.e., the MUST risk category using BMI calculated by SH) was 88.6% when the MUST risk category was obtained by BMI calculated by KH, 84.2% by UL, and 77.1% by MUAC (data not shown in table). In the first case, the individuals who were classified into a discordant risk category were distributed in a fairly symmetrical way (with respect to the reference method, 5.2% classified into a higher-risk category, 6.2% classified into a lower-risk category). In the other two modes (BMI calculated by UL and BMI estimated by MUAC), residents who were classified into a discordant risk category were distributed asymmetrically, mainly in a higher-risk category, when using alternative measures (13.1% considering UL; 19.8% considering MUAC), and less frequently in a lower-risk category (2.5% considering UL; 3.3% considering MUAC) (Table 2).

The internal relative validity indices regarding the malnutrition risk classification by MUST are shown in Table 2. The classification using BMI calculated by KH had the highest value of specificity (the proportion of true negatives that are correctly identified by the test), whereas the assignment using BMI calculated by UL had the highest value of sensitivity (the proportion of true positives that are correctly identified by the test). The classification using BMI calculated by KH tends to increase the specificity with respect to sensitivity, whereas in the other two classifications the values of sensitivity are higher than those of specificity. In contrast, the latter two methods have lower positive predictive values.

Discussion

The results of this study show that the use of alternative measures for estimating either height or BMI influence the resulting category of risk for malnutrition, according to MUST. Specifically, considering the mean value of height estimated by using KH appears to provide closer values to SH than those obtained using the UL, whereas the limits of agreement are larger considering the KH with respect to considering UL. Similar considerations can be made for BMI values, for which the Bland-Altman analysis showed an average of the differences that is very

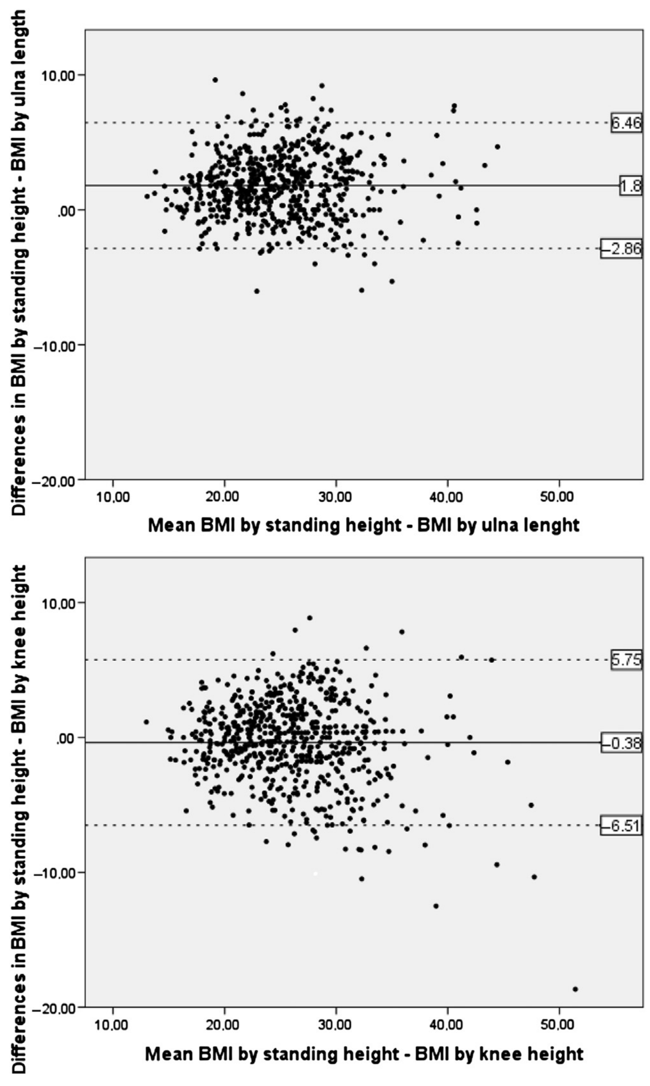

Fig. 1. Body mass index (BMI) calculated by standing height versus BMI calculated using alternative measurements (knee height, ulna length) to predict height: the Bland-Altman analysis. Dots represent the participants; continuous line represents the mean difference; and dotted lines the 95% limits of agreements (±1.96 SD).

Table 2
Classification by the MUST risk category*

Type of alternative measurements	MUST category using BMI calculated by standing height								
	Low risk n = 512 (%)	Medium risk n = 52 (%)	High risk n = 77 (%)	Total n = 641 (%)	Kappa (95% CI)	Sensibility (%)	Specificity (%)	Positive predictive value (%)	Negative predicted value (%)
BMI calculated by knee height	491 (95.7)	26 (50)	51 (66.2)	568 (88.6%)	0.81 (0.75–0.86)	82.3	95.9	83.6	95.5
BMI calculated by ulna length	447 (87.5)	26 (50)	67 (87.2)	540 (84.2%)	0.73 (0.66–0.78)	93.8	87.5	65.6	98.2
BMI predicted by MUAC	404 (78.9)	26 (50)	64 (82.1)	494 (77.1%)	0.54 (0.47–0.61)	86.9	78.9	51.1	96

BMI, body mass index; MUAC, middle-upper-arm circumference; MUST, Malnutrition Universal Screening Tool
* Residents classified in the same category considering the “reference method” (classification using BMI calculated by standing height) and values obtained using BMI when calculated or predicted by alternative measurements, with corresponding kappa values. Internal relative validity indices of MUST calculated using alternative measurements to predict either height or BMI.

close to zero when BMI is calculated using KH; although, with respect to the agreement with BMI calculated using UL, the limit of agreement is larger, which indicates greater variability. Therefore, specific analysis should be conducted either on the regression equation to reduce the mean difference between SH and height estimated by UL, or adding 1.8 kg/m^2 to BMI estimated by UL. The result should be a higher sensitivity and specificity.

In this analysis, SH was considered the reference method; therefore, BMI values that were calculated using this measure and the consequent classification into the risk for malnutrition category were considered as a reference. This is caused by the fact that the predicted values are usually more affected by bias (either in the measurement or in the application of the estimation formula) than direct measurements (only the bias related to the measurement). However, this may not be completely true in cohorts such as those assessed in the present study of elderly people affected by comorbidity in NHs. In fact, it can be difficult to obtain an accurate height measurement in this population because many of these individuals have difficulty standing upright as a consequence of chronic diseases, e.g., those involving the vertebral column. For these reasons, SH should underestimate the “real” height, especially for residents with clinically evident kyphosis, so the use of alternative measurements to predict both height and BMI can provide more reliable values than those obtained by direct measurement [24,25]. However, the results of a study conducted in Italy [26] on a cohort of older individuals showed a marked decrease in height with increasing age, although KH does not follow this trend. The authors argued that although height decreases with age, as also observed elsewhere [27] (mainly because of spinal deformity and thinning of the intervertebral disks), KH is not affected by similar mechanisms. However, the equations for estimating height by KH depend on age and, therefore already should be adjusted by reduction of height with aging [8]. Similar considerations can be made both on measurement of UL and height predicted by using this bone segment.

Moreover, a study conducted in Tuscany demonstrated that methods to predict stature from KH can be correctly and usefully applied to an older population in central Italy, and suggested the routine measurement of occiput-to-wall distance as an indirect indicator of the severity of kyphosis [24].

The level of agreement of the classification according to MUST, when obtained using BMI calculated by SH compared with that obtained using BMI calculated both by the predicted height and by MUAC, was “fair-good,” with higher kappa values when predicted height was used rather than MUAC. The classification by risk category using BMI calculated by KH was the most similar to that obtained using BMI calculated by SH (88.4% of the individuals were classified in the same way), and the residents classified into discordant risk categories were distributed fairly symmetrically. In contrast, the other two classifications showed a lower percentage of individuals classified in the same way (the lowest when using BMI predicted by MUAC), with a trend toward overestimating the risk for malnutrition. These results also emerged when considering indices of the internal relative validity of MUST.

Some researchers [28] have shown that BMI is effective in the identification of severe malnutrition with regard to older individuals and patients with cancer, whereas BMI tends to underestimate mild or moderate risk, especially in the setting of fluid retention or ascites. In these cases, the combined use of other parametric variables, including measurement of MUAC, which is less sensitive to variations in the amount of fluid, has been suggested. Other studies have confirmed these considerations [27,29]. These observations at least partially could explain the marked difference in classification according to MUST between using BMI calculated by SH compared with that obtained using BMI that is predicted—as a range—by MUAC. If this reasoning were true, then the classification by using MUAC would most likely be more correct than the other classification, and in any case, should be considered as a warning of a potential risk situation. Moreover, in a recent study conducted among older individuals in various European cities [30], MUAC emerged as the strongest predictor of mortality; therefore, it is a parameter that must be considered in the overall evaluation of these individuals. Furthermore, the possibility of being easily measured even when the patients are bedridden or disabled makes it easy to use MUAC in settings such as NHs, in which other methods of evaluation often are not applicable. Similar considerations can be made regarding the applicability of KH and UL to predict height. Therefore, although the use of alternative anthropometric measurements introduces a bias both in calculation and estimation of BMI and, consequently, in classification by malnutrition risk category, the use of the predicted height or BMI make it possible to also screen the individuals for whom it is not possible to detect direct anthropometric measurements.

The MUST was designed to identify needs for nutritional intervention, as suggested in its management guidelines; using MUST is inexpensive, and it has high applicability (ease of use, speed, generally associated with high compliance, and has high reproducibility and validity with respect to other screening tools) [5]. As a result, among all of the screening tools that are available to detect the risk for malnutrition, MUST is the one that most fulfills the aims of public health. The suggested management guidelines vary based on risk category and constitute non-invasive, low-cost, and safe interventions, which are as follows: repeat screening, documenting food intake for 3 d consecutively, improving nutritional intake, referring to a dietitian and/or nutritional support team, improving local policies, and monitoring and reviewing the care plan. For these reasons, the overestimation of the risk for malnutrition in the presence of a low percentage of false negatives (the individuals are misclassified into lower-risk category) on the one hand guarantees the activation of early intervention toward those who really need it, which is aimed at preventing and treating; on the other hand, it does not constitute an economic waste or a health risk for those who are wrongly classified into a higher-risk category.

One limitation of this study is the small number of individuals included with respect to the whole sample: it was possible to detect all the anthropometric measurements for only 641 older individuals in NHs (22.9% of the individuals enrolled); for the majority of the older people it was not possible to detect all the measurements for reasons reported in this article. This data also should be considered a strength of our work: in fact, in almost 80% of the NH residents, it was not possible to measure height and/or weight.

Another limitation is in the high number (N = 89) of observers who were enrolled for the measurements. These individuals are not researchers but instead are members of the staff of each NH whose directors voluntarily joined the survey. This might have limited the reliability of the measures, although the observers were specifically trained. The choice was made to let the operators directly involved and responsible to stimulate their awareness on health and quality of care in NHs, and to provide them with operational tools to be used right away (regardless of the research). Additionally, this strategy allowed us to evaluate the applicability of the tools for assessing the risk for malnutrition, making this study not only research in a narrow sense but also an interventional study aimed at offering a training opportunity to NH operators. This work involves the assessment and management of the risk for malnutrition through the correct and routine detection of simple anthropometric measurements, as suggested previously [31–33]. We used the scales and stadiometers that were already available in the NH (although this fact can be considered a limit with regard to detection homogeneity), to obtain a potential immediate effect on the nutritional outcome. However, the “therapeutic” relationship between the residents and the operators could have helped in the detection of the measurements, which is a fundamental aspect considering the general characteristics of these individuals (frail elderly with comorbidities, disabilities, and cognitive impairment). The specific training conducted slightly before (~1 wk) the data collection also should have increased the accuracy and precision of the measurements. However, it is necessary to emphasize that, according to some studies [31], NH staffs tended to underestimate the weight loss of residents, although they weigh them on a monthly basis. This could lead to an underestimation of the risk for malnutrition. However, this fact does not exempt us from considering that interventions such as this one should always have as their main aim to provide to those who work in the NHs the most appropriate and suitable tools for management of specific needs and, consequently, to improve the overall health of those people. The limits of the survey related to the study design also should be considered strengths to describe the reliability of the risk assessment in practice.

Conclusion

Considering the results of the study and the considerations discussed here, we propose, for similar targets (elderly individuals in NHs) and with MUST used as a screening tool, that it is best to determine the risk category by using SH when possible (i.e., when it is possible to measure SH with standard methods). When this approach is not possible, we recommend using alternative measurements (primarily UL due to its highest sensitivity) to predict height. Furthermore, we recommend comparing these evaluations with those obtained using MUAC to predict BMI. Finally, we recommend subsequent assessments or clarification if the two classifications (those obtained with either standing or predicted height with respect to those obtained with MUAC) lead to different risk categories.

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References

[1] Törmä J, Winblad U, Cederholm T, Saletti A. Does undernutrition still prevail among nursing home residents? Clin Nutr 2013;32:562–8.
[2] Verbrugghe M, Beeckman D, Van Hecke A, Vanderwee K, Van Herck K, Clays E, et al. Malnutrition and associated factors in nursing home residents: a cross-sectional, multi-centre study. Clin Nutr 2013;32:438–43.
[3] Neyens J, Halfens R, Spreeuwenberg M, Meijers J, Luiking Y, Verlaan G, et al. Malnutrition is associated with an increased risk of falls and impaired activity in elderly patients in Dutch residential long-term care (LTC): a cross-sectional study. Arch Gerontol Geriatr 2013;56:265–9.
[4] Labossiere R, Bernard MA. Nutritional considerations in institutionalized elders. Curr Opin Clin Nutr Metab Care 2008;11:1–6.
[5] Elia M, Stratton RJ. Considerations for screening tool selection and role of predictive and concurrent validity. Curr Opin Clin Nutr Metab Care 2011;14:425–33.
[6] Stratton RJ, Hackston A, Longmore D, Dixon R, Price S, Stroud M, et al. Malnutrition in hospital outpatients and inpatients: prevalence, concurrent validity and ease of use of the ‘malnutrition universal screening tool’ (‘MUST’) for adults. Br J Nutr 2004;92:799–808.
[7] Isenring EA, Banks M, Ferguson M, Bauer JD. Beyond malnutrition screening: appropriate methods to guide nutrition care for aged care residents. J Acad Nutr Diet 2012;112:376–81.
[8] Elia M. The “MUST” Report. Nutritional Screening of adults: a multidisciplinary responsibility. Development and use of the “Malnutrition Universal Screening Tool” (“MUST”) for adults. Redditch: Malnutrition Advisory Group (MAG), a Standing Committee of the British Association of Parenteral and Enteral Nutrition (BAPEN); 2003.
[9] British Association for Parenteral and Enteral Nutrition. The “MUST” explanatory booklet. Available at http://www.bapen.org.uk/screening-for-malnutrition/must/introducing-must. Accessed on Dec 10, 2013.
[10] Barbosa VM, Stratton RJ, Lafuente E, Elia M. Ulna length to predict height in English and Portuguese patient populations. Eur J Clin Nutr 2012;66:209–15.
[11] Auyeung TW, Lee JS, Kwok T, Leung J, Leung PC, Woo J. Estimation of stature by measuring fibula and ulna bone lenght in 2443 older adults. J Nutr Health Aging 2009;13:931–6.
[12] Madden AM, Tsikoura T, Stott DJ. The estimation of body height from ulna length in healthy adults from different ethnic groups. J Hum Nutr Diet 2012;25:121–8.
[13] Aparecida Leandro-Merhi V, Luiz Braga de Aquino J, Gonzaga Teixeira de Camargo J. Agreement between body mass index, calf circumference, arm circumference, habitual energy intake and the MNA in hospitalized elderly. J Nutr Health Aging 2012;6:128–32.
[14] Ritz P. Validity of measuring knee-height as an estimate of height in diseased French elderly persons. J Nutr Health Aging 2004;8:386–8.
[15] Hickson M, Frost G. A comparison of three methods for estimating height in the acutely ill elderly population. J Hum Nutr Diet 2003;16:13–20.
[16] Frid H, Thors Adolfsson E, Rosenblad A, Nydahl M. Agreement between different methods of measuring height in elderly patients. J Hum Nutr Diet 2013;26:504–11.
[17] Lohman TG, Roche AF, Martorell R. Manuale di riferimento per la standardizzazione antropometrica. Milano: EDRA Medical Publishing & New Media; 1992.
[18] Bland JM, Altman DG. A note on the use of the intraclass correlation coefficient in the evaluation of agreement between two methods of measurement. Comput Biol Med 1990;20:337–40.
[19] Bland JM, Altman DG. Measuring agreement in method comparison studies. Stat Methods Med Res 1999;8:135–60.
[20] Kottner J, Audigé L, Brorson S, Donner A, Gajewski BJ, Hróbjartsson A, et al. Guidelines for Reporting Reliability and Agreement Studies (GRRAS) were proposed. J Clin Epidemiol 2011;64:96–106.

[21] Ludbrook J. Statistical techniques for comparing measurers and methods of measurement: a critical review. Clin Exp Pharmacol Physiol 2002;29:527–36.
[22] Altman DG, Bland LM. Diagnostic test 1: sensitivity and specificity. BMJ 1994;308:1552.
[23] Altman DG, Bland LM. Diagnostic test 2: predictive values. BMJ 1994;309:102.
[24] Pini R, Tonon E, Cavallini MC, Bencini F, Di Bari M, Masotti G, et al. Accuracy of equations for predicting stature from knee height, and assessment of statural loss in an older italian population. J Gerontol A Biol Sci Med Sci 2001;56:B3–7.
[25] Di Bari M, Chiarlone M, Matteuzzi D, Zacchei S, Pozzi C, Bellia V, et al. Thoracic kyphosis and ventilatory dysfunction in unselected older persons: an epidemiological study in Dicomano, Italy. J Am Geriatr Soc 2004;52:909–15.
[26] Perissinotto E, Pisent C, Sergi G, Grigoletto F. Enzi G for the ILSA Working Group. Anthropometric measurements in the elderly: age and gender differences. Br J Nutr 2002;87:177–86.
[27] Omran ML, Morley JE. Assessment of protein energy malnutrition in older persons, part I: history, examination, body composition, and screening tools. Nutrition 2000;16:50–63.
[28] Campillo B, Paillaud E, Uzan I, Merlier I, Abdellaoui M, Perennec J, et al. Comité de Liaison Alimentation-Nutrition. Value of body mass index in the detection of severe malnutrition: influence of the pathology and changes in anthropometric parameters. Clin Nutr 2004;23:551–9.
[29] López-Contreras MJ, Torralba C, Zamora S, Pérez-Llamas F. Nutrition and prevalence of undernutrition assessed by different diagnostic criteria in nursing homes for elderly people. J Hum Nutr Diet 2012;25:239–46.
[30] De Hollander EL, Bemelmans WJ, de Groot LC. Association between changes in anthropometric measure and mortality in old age: a role for mi-upper arm circumference? J Am Med Dir Assoc 2013;14:187–93.
[31] Maas ML, Specht JP, Buckwalter KC, Gittler J, Bechen K. Nursing home staffing and training recommendations for promoting older adults' quality of care and life: Part 1. Deficits in the quality of care due to understaffing and undertraining. Res Gerontol Nurs 2008;1:123–33.
[32] Simmons SF, Peterson EN, You C. The accuracy of monthly weight assessments in nursing homes: implications for the identification of weight loss. J Nutr Health Aging 2009;13:284–8.
[33] Shipman D, Hooten J. Are nursing homes adequately staffed? The silent epidemic of malnutrition and dehydration in nursing home residents. Until mandatory staffing standards are created and enforced, residents are at risk. J Gerontol Nurs 2007;33:15–8.