ORIGINAL RESEARCH

Comparison of three methods for measuring height in rehabilitation inpatients and the impact on Body Mass Index classification: an open prospective study

Running head: Comparing height measurements and impact on BMI

Accepted: April 2017

Karen E MCDUGALL,¹ Alison J STEWART,¹ Alison M ARGIRIOU,¹ Catherine E HUGGINS² and Peter W NEW^{3,4,5}

¹*Nutrition and Dietetics, Rehabilitation and Aged Care Services, Kingston Centre, Community and Allied Health, Monash Health, Cheltenham, Victoria, Australia*

²*Department of Nutrition, Dietetics and Food, Monash University and Allied Health Research Unit, Monash Health, Victoria, Australia*

³*Medicine Program, Rehabilitation and Aged Care Services, Monash Health, Victoria, Australia*

⁴*Epworth-Monash Rehabilitation Medicine Unit, Southern Medical School, Monash University, Victoria, Australia*

⁵*Department of Epidemiology and Preventive Medicine, School of Public Health and Preventive Medicine, Faculty Medicine, Nursing and Health Sciences, Monash University, Victoria, Australia*

K. E. McDougall, BNutrDiet/BAppHSc, APD, Dietitian

A. J. Stewart MSc, APD, Clinical Manager

A. M. Argiriou, MNutrDiet/BSc, APD, Dietitian

C. E. Huggins, PhD, Senior Lecturer,

P. W. New, PhD, Senior Lecturer

Correspondence: K. McDougall, Kingston Centre, Monash Health, Nutrition & Dietetics Department, Warrigal Rd, Cheltenham, Victoria, Australia 3192. Tel.:(03) 9265 1000 and ask for pager 8256; Fax: (03) 9265 2376; Email: karen.mcdougall@monashhealth.org.

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/1747-0080.12361

Abstract

Aim: To compare standing height, estimated current height and demi-span estimated height and examine their impact on Body Mass Index (BMI) classification.

Methods: Cross-sectional data was collected on one hundred and four patients admitted to an adult rehabilitation ward and seen by the dietitian. Patient's standing, estimated current height and demi-span estimated height were collected and grouped by age: 19-64 and ≥65 years.

Results: The limits of agreement (95% confidence interval) for estimated current height compared with standing height were +9.9 cm and -7.9 cm, in contrast to +8.7 cm and -14.3 cm for demi-span estimated height. Demi-span underestimated height when compared with standing height in both age groups, 19-64 years: (mean ± SD) 3.0±6.5 cm (P=0.001, n=68); and ≥65 year age group 4.0±6.0 cm (P<0.001, n=36) resulting in a significantly greater mean BMI (ANOVA P<0.001, P=0.02). In the 19-64 and ≥65 year age groups, 3% (2/68) and 10% (4/36) of patients, respectively, had a different BMI classification using demi-span estimated height compared with standing height.

Conclusions: Estimated current height is a simple and practical alternative if standing height is unable to be obtained when performing a nutrition assessment. Demi-span estimated height should be used with caution when calculating BMI to assess nutritional status, particularly in the elderly.

Key words: anthropometry, height, body mass index, nutritional assessment, rehabilitation.

Introduction

An accurate height measurement is required for nutritional assessment in order to calculate Body Mass Index (BMI), as well as to determine ideal body weight and basal metabolic rate which are important for the estimation of energy requirements.¹⁻² Most validated nutrition screening and assessment tools rely on a height measurement to inform a nutrition diagnosis, or identify if a patient is at risk of malnutrition.³⁻⁷ As height is squared in the BMI calculation, a small variance in height will have a large effect on the BMI.⁸ BMI is a strong predictor of mortality, with studies showing individuals classified by their BMI as underweight or overweight/obese are at higher risk of mortality than those within the healthy weight range.^{9,10} Whilst 55% of the Australian adult population is overweight or obese (BMI >25kg/m²),¹¹ the average BMI of an elderly rehabilitation inpatient is 23kg/m² (lower end of healthy weight range).^{12,13} Inaccurate height measurement therefore has the potential to adversely impact on optimal nutrition management.

Current standing height is recognised as the ‘gold standard’ when calculating BMI, including in the elderly.¹²⁻¹⁵ However, due to changes in posture, spinal deformities and inability of the patient to stand upright, it is not always possible to measure height accurately. Patients in the rehabilitation setting may have medical reasons preventing them from standing, including lower limb or pelvis fractures, paralysis, postural hypotension and severe infections.¹⁶ In these situations, clinicians must use other methods for obtaining a patient’s height.

Alternative methods for estimating height include demi-span,¹⁷ arm span,¹⁸ ulna length,¹⁹ knee height²⁰ and estimated current height.²¹ Whilst studies have identified estimated current height as a valid and reliable method, there are limited studies comparing estimated current height to standing height within the adult inpatient rehabilitation population of both under and over 65 years of age.^{12,18-26} Furthermore, in clinical practice, height is often obtained by self-report and rarely measured due to inadequate time, resources, or inability of the patient to stand upright.^{13,16,22,27-28}

It is important to note that surrogate height estimates utilising long bone measurements such as demi-span, ulna length and knee height, report maximum adult height and do not change with age, unlike standing height.^{13,17,29-33} From the age of 30 to 80 years, standing height can reduce by 5cm in men and 8cm in women.³¹ Demi-span was used in this study to determine its suitability in our adult rehabilitation inpatient population compared with current estimated or standing height. Demi-span was chosen due to its ease of use, the ward dietitian's familiarity with this method, and its inclusion as a surrogate height measurement in both the Malnutrition Universal Screening Tool (MUST)³ and Mini Nutritional Assessment (MNA)^{®.5} Demi-span estimated height is a measurement taken from an individual's outstretched arm and standing is not required.¹⁷ The demi-span measurement is then entered into an equation to estimate maximum adult height. Bassey's demi-span equation was used in this study due to strong inter-rater reliability, validity and versatility of using the equation with our study group.¹⁷

The primary aim of this study was to compare three different methods of measuring height, and determine their impact on BMI classification. A secondary aim was to determine if demi-span is an accurate alternative height measurement.

Methods

This was an open prospective study of admissions to a rehabilitation ward in Victoria, Australia performed over a two year period. The ward managed patients with a range of impairments including neurological conditions (40%), deconditioning following surgery or acute medical illness (35%), and orthopaedic conditions (25%). Patients were excluded if they had a length of stay of less than seven days, died during admission, or were transferred to acute hospital and did not return. Data was collected on all patients seen by the dietitian and included the collection of demi-span and

estimated current height. Staff collecting the required data did change throughout the study, however the methodology used shows good inter-rater reliability.¹⁷

Evaluated variables included age on admission, gender, standing height, estimated current height, demi-span estimated height and body weight. These were recorded on a standardised data collection form and subsequently entered into a password-protected database for analysis.

Standing height was measured using a permanent stadiometer when the patient was able to stand upright during their admission. The physiotherapist measured standing height after estimated current height was obtained to eliminate reporter bias. Patients had footwear removed for the measurement, were asked to stand upright, looking straight ahead with the head upright and not tilted, with feet flat and heels against the wall, and readings recorded to the nearest 0.1 cm.

Patient's body weight was measured by nursing within the first week of admission on chair scales, wheelchair platform scales or via hoist, depending on the patient's mobility, and recorded to the nearest 0.1kg. All scales were calibrated. The weight was documented on a weight chart or in the patient's medical file.

Demi-span was measured by the dietitian with the patient sitting or lying, from their sternal notch to the web between the middle and ring fingers with the palm forwards. If the patient could not fully outstretch their arm, the measurement was not taken and the patient was excluded from the study. Height was calculated from the demi-span measurement using Bassey's¹⁷ formula:

$$\textbf{Female: Height in cm} = (1.35 \times \text{demi-span cm}) + 60.1$$

$$\textbf{Male: Height in cm} = (1.4 \times \text{demi-span cm}) + 57.8$$

Estimated current height was collected within 1-2 days of admission by the dietitian or nutrition assistant who asked the patient, family or carer the patient's current height. Collection of estimated current height was routine clinical practice, and the objective of the project was not

divulged in order to prevent recall bias. Estimated current height was obtained from the family or carer if the patient was unable to report due to impaired cognition or communication deficits, as perceived by the dietitian or nutrition assistant and after corroboration with other members of the rehabilitation team. No formal screening of cognition was used for this purpose. Patients were excluded from the study if standing height, demi-span and estimated current height were not all able to be collected.

Body Mass Index was calculated by weight divided by height squared,⁸ where height was measured by standing, demi-span or estimated current height. BMI reference ranges for the 19-64 year age group were: underweight ($<18.5\text{kg/m}^2$), healthy weight ($18.5\text{--}24.9\text{kg/m}^2$), overweight ($25\text{--}29.9\text{kg/m}^2$) and obese ($\geq 30\text{ kg/m}^2$).⁸ As per Lipschitz,¹³ the ≥ 65 year age group BMI reference ranges were: underweight ($<22\text{ kg/m}^2$), healthy weight ($22\text{--}27\text{ kg/m}^2$), and overweight ($>27\text{ kg/m}^2$).

Approval was obtained from the Monash Health Human Research and Ethics Committee to conduct this project.

Patients were divided into two age groups (19-64 years old and ≥ 65 years old) for comparing the impact of the various height measurements on BMI due to different BMI classifications for the elderly.^{13,29,30} Normally distributed data are presented as mean and standard deviation (SD). Categorical data are presented as number and percentage. Nonparametric data are presented as median and interquartile range. Comparison between standing height, estimated current height and demi-span estimated height were analysed using repeated measures ANOVA and subsequent Bonferroni *Post hoc* comparison when appropriate. Bland-Altman³⁴ plots were used to assess agreement between standing height and estimated height (current reported and demi-span). Cohen's Kappa coefficient was used to assess agreement in BMI classification when BMI was calculated

using standing height compared with estimated current height. $P < 0.05$ was considered statistically significant. Statistical analysis was performed using IBM SPSS® version 20.

Results

104 patients were seen by the dietitian (median age 60 years, range 19-91) and included in this project. The median age (IQR) for the 19-64 year age group was 56 (45.0, 59.0) years, with a median admission weight (IQR) of 72.2kg (58.0, 91.0); 36 were female (53%). The ≥ 65 year age group had a median age (IQR) of 71 (67.7, 76.0) years, range 65-91 years, median admission weight (IQR) was 70.5kg (58.6, 80.8); 16 were female (44%).

Mean estimated current height was similar in both the 19-64yo age group (Table 1) and ≥ 65yo age group (Table 2). For the entire patient cohort agreement between estimated current height and standing height showed no systematic bias between the measures. The mean difference between estimated current height and standing height was +1 cm, and the upper and lower limits of agreement (95% confidence interval) were 9.9 cm and -7.9 cm respectively (Figure 1). Patients were classified as underweight, healthy weight, overweight or obese by the BMI calculation. BMI classification using estimated current height agreed strongly with BMI classification using standing height in both the younger and older age groups (Table 1 & 2).

The mean ($\pm$ SD) demi-span estimated height was significantly lower compared with standing and estimated current height in both the 19-64yo age group (Table 1) and ≥ 65yo age groups (Table 2). The mean difference ($n=104$) between demi-span estimated height and standing height was -3 cm with upper and lower limits of agreement (95% CI) of 8.7 cm and -14.3 cm. There was no systematic bias between the measures.

Demi-span estimated height used to calculate BMI led to more patients in the 19-64 age group (Table 1) classified as obese and fewer as underweight and in the e65yo age group (Table 2) more were classified as overweight and fewer as healthy weight compared with BMI classifications based on standing height.

Discussion

This study found measured standing height and estimated current height produced similar results with comparable BMI classifications in both age groups analysed (19-64 and e65yo). In comparison, demi-span underestimated height in both age groups, and subsequently classified more patients as overweight or obese. This study demonstrated that estimated current height may be used as an alternative to measured height within this inpatient rehabilitation setting. This is an important finding in ensuring efficiency of clinician's time, accuracy of BMI classification and subsequent nutritional management, and is also less obtrusive for the patient.

There are important clinical implications from our results. Clinicians need to be aware of how the BMI calculation is derived, especially in the elderly. Using current height compared to estimated maximum adult height in the elderly will impact on BMI calculation which subsequently informs the nutrition assessment.^{21,26,35} Screening tools such as the MUST³ and MNA^{®5} recommend standing height to calculate BMI for malnutrition risk scoring, and if unable to obtain, recommend alternative height measurements of demi-span, ulna length and knee length. They do not use estimated current height as an alternative. Our results suggest that estimated current height may be a more appropriate alternative if unable to measure standing height in an inpatient rehabilitation population similar to that used in this study.

Whilst our study found good agreement between standing height and estimated current height, other studies have not.³⁶⁻³⁸ This difference may be due to younger study populations overestimating current height, the environment in which the study was conducted (community and emergency department), cultural differences and other variables obtained that may bias estimated height such as estimated weight.³⁶⁻³⁸ This is supported by Mozumdar & Liguori's³⁹ findings that misreporting of estimated current height was related to age, ethnicity, in addition to gender and body weight. Their use of correction equations when using estimated current height based on the above variables is an important consideration for future studies.³⁹

Demi-span underestimated height in the study cohort by up to 14.3 cm, therefore caution is suggested when using this alternative measurement. A possible reason for variation may have been the inclusion of demi-span measurements for patients lying, as well as sitting, however this was a practical choice for this study in the clinical setting. Frid *et al*²⁵ also concluded that demi-span should be considered as a 'last resort'. Misclassification of overweight in the elderly by use of demi-span estimated height may have implications in terms of unwarranted dietary restrictions or interventions.

It was observed in this study and others⁴⁰ that some elderly patients had difficulty outstretching their arm and facing their palm forward for the demi-span measurement to be obtained. Whilst patients were excluded if this measurement could not be performed, it does suggest that the demi-span measurement may not be practical for estimating height in this study group.

Strengths of this study include that this is the first study focusing on height measurement methods and their impact on BMI within the general rehabilitation inpatient setting. Measured standing height was performed by a physiotherapist and patient estimated current height was collected by the ward dietitian or nutrition assistant to reduce bias in the data collection.

Importantly, we have shown that when patients cannot stand upright, estimated current height is preferred to the demi-span. Whilst this study was conducted on an inpatient rehabilitation ward, utilisation of estimated current height as an alternative height measurement could be applied in other rehabilitation and aged-care inpatient and community settings. A subject's cognitive capacity should be considered and utilisation of family or carers to estimate height if required, similar to the methodology of our study.

Whilst numerous ward staff were involved in measuring standing height and demi-span estimated height, as would happen in clinical practice, previous studies have shown that inter-rater reliability of both measurements is strong.¹⁷ Interview bias may have occurred with collection of estimated current height due to more than one staff member collecting this information. Whilst Cohen's Kappa Coefficient reported the agreement in BMI classification when calculated using standing height compared with estimated current height, this may not represent all individual changes in BMI classification that may result from using the different height methodology.

A limitation was that participants in the study were those who were referred to the ward dietitian, highlighting their possible higher risk of malnutrition, causing an altered BMI compared to the general population. However, our previous study in this similar rehabilitation setting indicates that 90% of patients are malnourished or at risk of malnutrition⁴¹ therefore this should not markedly alter the generalisability of the findings.

A further study utilising a larger sample size within the inpatient rehabilitation population to validate the accuracy of estimated current height is recommended, as this would be a practical and valuable bedside tool for dietitians. Consideration of factors which may impact on estimated current height including patient cognition, gender and ethnic background are recommended.^{42,43}

In conclusion, if standing height is unable to be obtained in the inpatient rehabilitation setting, estimated current height is a suitable alternative. We suggest demi-span estimated height should be used with caution, particularly in the elderly, when calculating BMI due to the potential impact on BMI classification in relation to nutritional assessment and subsequent nutrition management of a patient.

Funding source

Grant support was obtained from the William Angliss (Victoria) Charitable Fund to assist with publication of these results.

Conflict of interest

The authors have no conflict of interest to report.

Authorship

Karen McDougall: Contribution to data collection, facilitator of other data collectors (dietitians, nutrition assistants, physiotherapists), refinement of data collected including data input into results spreadsheet, interpretation of results, formulation of key results to publish, liaison with authors regarding results and discussion regarding content to publish, completion of first draft and further revisions of manuscript following feedback from all below contributing authors.

Alison Stewart: Contribution to conception of the project design, data collection methodology, interpretation of results to publish, formulation of key concepts to include in discussion, critically reviewed final draft of manuscript and approved final version for publication.

Alison Argiriou: Contribution to conception of the project design, data collection methodology, facilitator of other data collectors (dietitians, nutrition assistants and physiotherapists), refinement of data collected including data input into results spreadsheet, critically reviewed final draft of manuscript and approved final version for publication.

Catherine Huggins: Contribution to analysis of results, formulation of key results to publish, critically reviewed final draft of manuscript and approved final version for publication.

Peter New: Contribution to conception of the project design, data collection methodology, interpretation of results to publish, formulation of key concepts to include in discussion, critically reviewed final draft of manuscript and approved final version for publication.

References

- 1 Brown JK, Whittemore KT, Knapp TR. Is Arm Span an Accurate Measure of Height in Young and Middle-Age Adults? *Clin Nurs Res* 2000; **9**: 84-94.
- 2 Haboubi NY, Hudson PR, Pathy MS. Measurement of Height in the Elderly. *J Am Geriatr Soc* 1990; **38**: 1008-1010.
- 3 British Association for Parenteral and Enteral Nutrition (BAPEN). *The 'MUST' Explanatory Booklet. A Guide to the 'Malnutrition Universal Screening Tool' ('MUST') for Adults*. Redditch: BAPEN, 2003.
- 4 Kondrup J, Rasmussen HH, Hamberg O *et al*. Nutritional risk screening (NRS): a new method based on an analysis of controlled clinical trials. *Clin Nutr* 2003; **22**: 321-336.

- 5 Nestle Nutrition Institute. A Guide to completing the Mini Nutrition Assessment – Short Form (MNA®-SF). (Available from: <http://www.mna-elderly.com/>, accessed 7 December 2016).
- 6 Visvanathan R, Penhall R, Chapman I. Nutritional screening of older people in a sub-acute care facility in Australia and its relation to discharge outcomes. *Age Ageing* 2004; **33**: 260–265.
- 7 Laporte M, Villalon L, Payette H. Simple nutrition screening tools for healthcare facilities: development and validity assessment. *Can J Diet Pract Res* 2001; **62**: 26–34.
- 8 World Health Organisation. Global Database on Body Mass Index (BMI) Classification. (Available from: http://www.who.int/bmi/index.jsp?introPage=intro_3.html, accessed 27 May 2016).
- 9 Hollander EL, Van Zutphen M, Bogers RP *et al.* The Impact of Body Mass Index in Old Age on Cause-Specific Mortality. *J Nutr Health Aging* 2012; **16**: 100-106.
- 10 Winter J, MacInnis RJ, Wattanapenpaiboon N *et al.* BMI and all-cause mortality in older adults: a meta-analysis. *Am J Clin Nutr* 2014; **99**: 875-890.
- 11 Australian Bureau of Statistics. Gender Indicators, Australia, 2012. (Available from: <http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by+Subject/4125.0~Jan+2012~Main+Features~Overweight+and+obesity~3330>, accessed 7 June 2016).
- 12 Taylor AW, Grande ED, Gill TK, Chittleborough CR *et al.* How valid are self-reported height and weight? A comparison between CATI self-report and clinic measurements using a large cohort study. *Aust N Z J Public Health* 2006; **30**: 238-246.
- 13 Lipschitz DA. Screening for nutritional status in the elderly. *Prim Care* 1994; **21**: 55–67.

- 14 Keys A, Fidanza F, Karvonen MJ, Kimura N, Taylor HL. Indices of Relative Weight and Obesity. *J Chron Dis* 1972; **25**: 329-343.
- 15 Sorkin JD, Muller DC, Andres R. Longitudinal Change in Height of Men and Women: Implications for Interpretation of the Body Mass Index. *Am J Epidemiol* 1999; **150**: 969-977.
- 16 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* 2006; **203**: 887-893.
- 17 Bassey EJ. Demi-span as a measure of skeletal size. *Ann Hum Biol* 1986; **13**: 499-502.
- 18 Mitchell CO, Lipschitz DA. Arm Length Measurement as an Alternative to Height in Nutritional Assessment of the Elderly. *J Parenter Enteral Nutr* 1982; **6**: 226-229.
- 19 Auyeung TW, Lee JSW, Kwok T *et al.* Estimation of Stature by Measuring Fibula and Ulna Bone Length in 2443 Older Adults. *J Nutr Health Aging* 2009; **13**: 931-936.
- 20 Chumlea WC, Roche AF, Steinbaugh ML. Estimating stature from knee height for persons 60-90 years of age. *J Am Geriatr Soc* 1985; **33**: 116-120.
- 21 Burton NW, Brown W, Dobson A. Accuracy of body mass index estimated from self-reported height and weight in mid-aged Australian women. *Aust N Z J Public Health* 2010; **34**: 620-623.
- 22 Davidson J, Randall GK, Getz MA. Self-Reported Height, Calculated Height, and Derived Body Mass Index in Assessment of Older Adults. *J Nutr Elder* 2009; **28**: 359-371.
- 23 Palta M, Prineas RJ, Berman R *et al.* Comparison of Self-reported and measured height and weight. *Am J Epidemiol* 1981; **115**: 223-230.
- 24 Stewart AL. The Reliability and validity of self-reported weight and height. *J Chron Dis* 1982; **35**: 295-309.

- 25 Frid H, Adolfsson ET, Rosenblad A *et al.* Agreement between different methods of measuring height in elderly patients. *J Hum Nutr Diet* 2013; **26**: 504-511.
- 26 Sahyoun NR, Maynard LM, Zhang XL, Serdula MK. Factors Associated with Errors in Self-reported Height and Weight in Older Adults. *J Nutr Health Aging* 2008; **12**: 108-115.
- 27 WHO. The Expert Committee on the Use and Interpretation of Anthropometry in the Elderly. Uses and Interpretation of Anthropometry in the Elderly for the Assessment of Physical Status. Report to the Nutrition Unit of the World Health Organization. *J Nutr Health Aging* 1998; **2**: 5-17.
- 28 Kuczmarski MF, Kuczmarski RJ, Najjar M. Effects of Age on Validity of Self-Reported Height, Weight, and Body Mass Index: Findings from the Third National Health and Nutrition Examination Survey, 1988–1994. *J Am Diet Assoc* 2001; **101**: 28-34.
- 29 Hirani V, Mindell J. A comparison of measured height and demi-span equivalent height in the assessment of body mass index among people aged 65 years and over in England. *Age Ageing* 2008; **37**: 311-317.
- 30 Kwok T, Whitelaw MN. The use of armspan in nutritional assessment of the elderly. *J Am Geriatr Soc* 1991; **39**: 492-496.
- 31 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.
- 32 Hirani V, Aresu M. Development of New Demi-Span Equations From a Nationally Representative Sample of Older People to Estimate Adult Height. *J Am Geriatr Soc* 2012; **60**: 550-554.

- 33 Hirani V, Tabassum F, Aresu M *et al.* Development of New Demi-Span Equations from a Nationally Representative Sample of Adults to Estimate Maximal Adult Height. *J Nutr* 2010; **140**: 1475-1480.
- 34 Bland JM, Altman DG. Statistical Methods for Assessing Agreement between two methods of Clinical Measurement. *Lancet* 1986; **1**: 307-310.
- 35 Nishiwaki Y, Michikawa T, Eto N *et al.* Body Mass Index Misclassification Due to Kyphotic Posture in Japanese Community-Dwelling Adults Aged 65 Years and Older. *J Gerontol A Biol Sci Med Sci* 2011; **3**: 326-331.
- 36 Lu S, Su J, Xiang Q, Zhou J, Wu M. Accuracy of self-reported height, weight, and waist circumference in a general adult Chinese population. *Popul Health Metr* 2016; **14**: 30.
- 37 Silva FM, Figueira L. Estimated height from knee height or ulna length and self-reported height are no substitute for actual height in inpatients. *Nutrition* 2017; **33**: 52-56.
- 38 Ikeda N. Validity of Self-Reports of Height and Weight among the General Adult Population in Japan: Findings from National Household Surveys, 1986. *PLoS One* 2016; **11**: e0148297.
- 39 Mozumdar A, Liguori G. Corrective Equations to Self-Reported Height and Weight for Obesity Estimates Among U.S. Adults: NHANES 1999-2008. *Res Q Exerc Sport* 2016; **87**: 47-58.
- 40 Kirk SFL, Hawke T, Sandford S *et al.* Are the measures used to calculate BMI accurate and valid for the use in older people? *J Hum Nutr Diet* 2003; **16**: 366-367.
- 41 McDougall KE, Cooper PL, Stewart AJ, Huggins CE. Can the Mini Nutritional Assessment (MNA®) be used as a Nutritional Evaluation Tool for Subacute Inpatients over an Average Length of Stay? *J Nutr Health Aging* 2015; **19**: 1032-1036.
- 42 Rowland ML. Self-reported weight and height. *Am J Clin Nutr* 1990; **52**: 1125-33.

- 43 Gillum RF, Sempos CT. Ethnic variation in validity of classification of overweight and obesity using self-reported weight and height in American women and men: the third National Health and Nutrition Examination Survey. *BMC Nutr J* 2005; **4**: 27.

Author Manuscript

Minerva Access is the Institutional Repository of The University of Melbourne

Author/s:

McDougall, KE;Stewart, AJ;Argiriou, AM;Huggins, CE;New, PW

Title:

Comparison of three methods for measuring height in rehabilitation inpatients and the impact on body mass index classification: An open prospective study

Date:

2018-02-01

Citation:

McDougall, K. E., Stewart, A. J., Argiriou, A. M., Huggins, C. E. & New, P. W. (2018). Comparison of three methods for measuring height in rehabilitation inpatients and the impact on body mass index classification: An open prospective study. NUTRITION & DIETETICS, 75 (1), pp.123-128. <https://doi.org/10.1111/1747-0080.12361>.

Persistent Link:

<http://hdl.handle.net/11343/293049>