HHS Public Access
Author manuscript
J Nutr Health Aging. Author manuscript; available in PMC 2018 January 02.

Published in final edited form as:
J Nutr Health Aging. 2017 ; 21(3): 262–265. doi:10.1007/s12603-016-0761-7.

VALIDITY OF KNEE-ESTIMATED HEIGHT TO ASSESS STANDING HEIGHT IN OLDER ADULTS: A SECONDARY LONGITUDINAL ANALYSIS OF THE MEXICAN HEALTH AND AGING STUDY

C. GARCÍA-PEÑA[1] and **M.U. PÉREZ-ZEPEDA**[2]

[1]Head of the Research Office at the Instituto Nacional de Geriatría, Mexico City, México

[2]Geriatric Epidemiology Research Department at Instituto Nacional de Geriatría, Mexico City, México

Abstract

Objective—The main objective was to test the validity of height estimated by knee height in Mexican older adults, as a surrogate for standing height.

Design—Cohort study.

Setting—Data were drawn from the first and third waves of the Mexican Health and Aging Study.

Participants—Included participants were community-dwelling 50-year or older adults with measured height at baseline and in follow-up. Subjects with a lower limb fracture in the follow-up were excluded.

Measurements—Main measurements were baseline standing height and 11-year follow-up and knee-estimated height in follow-up. Population specific equations were used to estimate standing height from knee height. Comparisons between baseline standing height and knee-derived height were done with simple correlations, limits of agreement (Bland-Altman plot) and Deming regressions.

Results—A total of 136 50-year or older adults were followed-up for eleven years, with a mean age of 60. There was a positive correlation between knee-estimated height and baseline standing height of 0.895 ($p<0.001$) for men and of 0.845 ($p<0.001$) for women. Limits of agreement for men were from −6.95cm to 7.09cm and for women from −6.58cm to 8.44cm.

Conclusion—According to our results, knee-estimated height could be used interchangeably with standing height in Mexican older adults, and these results might apply also to other populations.

Corresponding author: Mario Ulises Pérez Zepeda Geriatric Epidemiology Research Department at the Instituto Nacional de Geriatría, Periférico Sur 2767, colonia San Jerónimo Lídice, delegación La Magdalena Contreras, ciudad de México, Distrito Federal, México. Phone number: +52 55 55739087, ulises.perez@me.com, mperez@inger.gob.mx.

Conflict of interest: Authors declare not to have conflict of interest.

Ethical Standards: The Helsinki declaration was used to follow ethical standards for research with human beings. The Institutional Review Boards or Ethics Committees of the University of Texas Medical Branch in the United States, the Instituto Nacional de Estadística y Geografía, the Instituto Nacional de Salud Pública. All study subjects signed an informed consent.

Keywords

Body height; body mass index; geriatric assessment; validation

Introduction

Standing height (SH) is one of the more common anthropometric measurements used in clinical settings and has a number of implications in health during the life course; ranging from a marker of development in early life to a component of the body mass index (BMI) in adulthood (1) and late life. However, SH is not constant and it is well known that humans reach a maximum height in early adulthood and from there on height continuously declines, which may not be considered as normal and rather be a manifestation of disease (e.g. osteoporosis) (2, 3).

A number of approximations to a reliable measurement (and in particular in late life) of height have been described in the literature (e.g. equations, formulas, etc.) (4–6). Dimensions of certain bones –and in particular the fibula/tibia– are quite stable across adulthood and its measurement can be used to estimate SH (4–8).

More recently it has come to the attention of researchers and clinicians the fact that height loss could have an important clinical relevance and that it may predict adverse outcomes (9, 10, 3, 11). Moreover, having an accurate approximation of SH is important when estimating BMI and other body composition parameters (e.g. skeletal muscle index), this is particularly true when it is not possible to measure SH in bedridden older adults or with limited mobility (8). In particular, having accurate BMI would aid in diminishing misclassification of older adults as obese when using the current SH (12, 13), or with low weight.

Having historical records of the maximal SH of a person would allow having a constant reference of each person, however both in clinical and research setting is rarely the case (4). Therefore, alternatives to assess maximum SH are equations derived from other anthropometric measurements. One of the most used for this purpose has been knee-estimated height (KeH), and equations have been developed for different populations of older adults, including Mexican older adults (5). Therefore, the aim of this report is to test the validity of height estimated by KeH Mexican older adults specific equations. We here hypothesize that KeH is equal to the SH measured in the past meaning that KeH is a proper equivalent of SH.

Methods

Design and Setting

This is a secondary analysis of the Mexican Health and Aging Study (MHAS), a cohort study that began in 2001 and has its last wave in 2015 (fourth wave). Complete methods and objectives are available elsewhere (14, 15). Regarding this report, 50-years or older adults with measurement of SH and KeH in the baseline wave and in the third one were analyzed. Baseline assessment included 15,402 subjects and a representative probabilistic sub-sample for anthropometric measurements was drawn (n=1,905) (14, 15). From this sub-sample only

1,320 were 50-years or older, and from these subjects, only 158 had also complete anthropometric measurements in 2012 follow-up. In addition those older adults that reported a lower limb fracture in 2012 (during the past 10-years) were not included (n=22), in order to avoid measurement bias of KeH due to the potential deformity of the limb caused by the fracture. The final sample consisted of 136 adults 50-year or older.

Measurements

Measurements were done by trained interviewers and certified in anthropometry, in both waves the same methods were used. A graded stadiometer was used to measure height in centimeters; the stadiometer was fixed to a wall in a 90° angle with the floor and the subject was asked to stand still with arms by the sides, the measurement was done from the highest point of the head to the ankles; this was repeated in two occasions and the average of the measurements in centimeters was used in this report. In order to assess KeH, the interviewers asked the older adult to be seated comfortably in a stool (with standardized height, brought to the site by the interviewer); with a goniometer a 90° angle was verified between the leg and the thigh (8). The average of two measurements in centimeters was used in the KeH equations (4). Specific equations for KeH in Mexican older adults were used (5), stratified by sex, as follows:

$$\text{Height in centimeters (women)} = 73.7 + (1.99 \times \text{knee estimated height in centimeters}) - (0.23 \times \text{age in years})$$

$$\text{Height in centimeters (men)} = 52.6 + (2.17 \times \text{knee estimated height in centimeters})$$

Statistical Analysis

In order to assess the validity of KeH in estimating maximum SH (using a SH from eleven years ago as a measurement of the closest parameter to maximum SH available in the dataset) the first step was to describe the differences between measurements as means and standard deviations (SD) of the differences (baseline SH minus current SH, current KeH minus current SH, and current KeH minus baseline SH); a paired t-test was performed in order to assess if there was a significant difference between measurements. To visually assess the correlation of the measurements scatter plots and the Spearman correlation were done. Bland-Altman plots were performed to assess limits of agreement and mean difference between measurements (with Pitman's test of difference in variance for this difference) (16). Finally, a Deming regression was performed to assess estimates (point beta coefficients along with 95% confidence intervals) taking into account the bias of error of measurements (17) for repeated diagnostic tests. All estimations were performed with STATA ©14 software and were stratified for sex.

Ethical Issues

The Institutional Review Boards or Ethics Committees of the University of Texas Medical Branch in the United States, the Instituto Nacional de Estadística y Geografía, the Instituto Nacional de Salud Pública. All study subjects signed an informed consent.

Results

A total of 136 subjects were followed-up for eleven years, the mean age at baseline was of 60 years (± SD 7.32); 59.72 years (± SD 7.47) for men and 60.1 years (± SD 7.05) for women. The frequency of women was of 53.1% (n=70) and 46.9% (n=66) of men (table 1).

Baseline SH mean for men was of 164.53cm (± SD 7.76) and for women was of 152.5cm (± SD 6.97). Current SH mean was of 162.06cm (± SD 7.97) for men and 149.05cm (± SD 6.29) for women; simultaneous measurement of KeH and the mean value was 157.82cm (± SD 8.72). There was a significant difference between baseline SH and current SH, with a mean difference of −2.46cm for men ($p<0.001$) and of −3.45cm for women ($p<0.001$); in contrast the difference between KeH and baseline SH was not significant in men (0.07cm, $p=0.86$) nor in women (1cm, $p=0.051$).

A significant correlation between baseline SH and KeH was found for men ($r=0.895$, $p<0.001$) and women ($r=0.845$, $p<0.001$) (figure 1). Limits of agreement assessed by the Bland Altman plots for men were from −6.95 to 7.09cm, the mean difference between measurements of 0.07 (95% CI −0.79 to 0.93) and the Pitman's test of difference in variance of 0.42 ($p<0.001$). Regarding women parameters, the limits of agreement were from −6.58 to 8.44cm and the mean difference of 0.93 (95% CI 0.035 to 1.82) and the Pitman's test of difference in variance of 0.42 ($p<0.001$) (figures 2a and 2b).

Finally regarding to the Deming regression parameters between baseline SH and KeH for men the beta coefficient was of 1.25 (95% CI 1.11–1.39, $p<0.001$); and for women the beta coefficient was of 1.34 (95% CI 1.14–1.53, $p<0.001$).

Discussion

According to our results KeH could be used interchangeably when no record of past height is available to estimate SH (as the closest parameter to maximum SH). Moreover, KeH is similar to maximum SH as shown by the lack of difference between KeH and baseline SH, and significantly different from simultaneous SH. Our longitudinal findings support previous research on using KeH as a surrogate or even as a more precise estimate of maximum SH rather than using current SH (18) The limits of agreement of both measurements are from −6.58 to 8.44cm (for the whole sample), a fair approximation to what maximum SH would have been. However, further research should aim at finding more accurate agreement, either by testing other KeH equations (4) or actually comparing to maximum height of the older adult.

Simultaneously measuring both SH and KeH is in some cirumstances feasible in a clinical setting and may aid the physician in taking decisions (19); and is routinely used in nutritional screening tools such as the Mini-nutritional Assessment (20). In addition, when a difference is evidenced in an older adult, should alert of possible osteoporosis (21, 10, 3, 11) and may point to the fact that the BMI (and other body composition parameters) should be calculated with the estimated value rather than with the measured one, because of overestimation of obesity (or missing low weight) in older adults or misclassification that could lead to restrictive diets (22) or other treatments (23). Testing this difference in clinical setting and research could also help in advancing the field of so-called osteo-sarcopenia (24), giving a practical measurement that could be added to calf circumference measurement (25) to test this problem in every-day care; however this is still to be clarified in the future.

In addition, some recent reports have shown that a reduction of height, estimated by the difference of current SH and KeH could predict adverse outcomes. Having a valid KeH could aid in advancing the field of knowing the significance of loosing height in older adults (3, 26, 27)

The main flaw of our study is the sampling method used to choose sub-sample of anthropometry in the different waves, resulting in a lower number of older adults with complete follow-up of measurements (14, 15). Nevertheless, this also could be taken as strength; the fact of having a cohort of over one hundred older adults with SH measurements eleven years apart was the basis of this validation. Further research should aim at testing this methodology in other populations and testing how the substitution of current height with KeH could change the categorization of BMI in addition to describing the significance of height loss when using the subtraction of KeH from SH when measured simultaneously.

References

1. Tanner JM. Normal growth and techniques of growth assessment. Clin Endocrinol Metab. 1986; 15(3):411–51.
2. Nayak S, Edwards DL, Saleh AA, Greenspan SL. Systematic review and meta-analysis of the performance of clinical risk assessment instruments for screening for osteoporosis or low bone density. Osteoporos Int. 2015; 26(5):1543–54. DOI: 10.1007/s00198-015-3025-1 [PubMed: 25644147]
3. Auyeung TW, Lee JS, Leung J, Kwok T, Leung PC, Woo J. Effects of height loss on morbidity and mortality in 3145 community-dwelling Chinese older women and men: a 5-year prospective study. Age Ageing. 2010; 39(6):699–704. DOI: 10.1093/ageing/afq101 [PubMed: 20817934]
4. Chumlea WC, Roche AF, Steinbaugh ML. Estimating stature from knee height for persons 60 to 90 years of age. J Am Geriatr Soc. 1985; 33(2):116–20. [PubMed: 3968366]
5. Mendoza-Nunez VM, Sanchez-Rodriguez MA, Cervantes-Sandoval A, Correa-Munoz E, Vargas-Guadarrama LA. Equations for predicting height for elderly Mexican Americans are not applicable for elderly Mexicans. American journal of human biology : the official journal of the Human Biology Council. 2002; 14(3):351–5. DOI: 10.1002/ajhb.10029 [PubMed: 12001092]
6. Weinbrenner T, Vioque J, Barber X, Asensio L. Estimation of height and body mass index from demi-span in elderly individuals. Gerontology. 2006; 52(5):275–81. [PubMed: 16974098]
7. Hickson M. Nutritional interventions in sarcopenia: a critical review. Proc Nutr Soc. 2015; :1–9. DOI: 10.1017/S0029665115002049
8. Hickson M, Frost G. A comparison of three methods for estimating height in the acutely ill elderly population. J Hum Nutr Diet. 2003; 16(1):13–20. [PubMed: 12581405]
9. Yoshimura N, Kinoshita H, Takijiri T, Oka H, Muraki S, Mabuchi A, et al. Association between height loss and bone loss, cumulative incidence of vertebral fractures and future quality of life: the Miyama study. Osteoporos Int. 2008; 19(1):21–8. DOI: 10.1007/s00198-007-0474-1 [PubMed: 17962917]
10. Moayyeri A, Luben RN, Bingham SA, Welch AA, Wareham NJ, Khaw KT. Measured height loss predicts fractures in middle-aged and older men and women: the EPIC-Norfolk prospective population study. J Bone Miner Res. 2008; 23(3):425–32. DOI: 10.1359/jbmr.071106 [PubMed: 17997714]

11. Hillier TA, Lui LY, Kado DM, LeBlanc ES, Vesco KK, Bauer DC, et al. Height loss in older women: risk of hip fracture and mortality independent of vertebral fractures. J Bone Miner Res. 2012; 27(1):153–9. DOI: 10.1002/jbmr.558 [PubMed: 22072593]
12. Sorkin JD, Muller DC, Andres R. Longitudinal change in height of men and women: implications for interpretation of the body mass index: the Baltimore Longitudinal Study of Aging. Am J Epidemiol. 1999; 150(9):969–77. [PubMed: 10547143]
13. Sorkin JD, Muller DC, Andres R. Longitudinal change in the heights of men and women: consequential effects on body mass index. Epidemiol Rev. 1999; 21(2):247–60. [PubMed: 10682261]
14. Wong R, Michaels-Obregon A, Palloni A. Cohort Profile: The Mexican Health and Aging Study (MHAS). Int J Epidemiol. 2015; doi: 10.1093/ije/dyu263
15. Wong R, Espinoza M, Palloni A. Mexican older adults with a wide socioeconomic perspective: health and aging. Salud Publica Mex. 2007; 49(Suppl 4):S436–47. [PubMed: 17724516]
16. Bland JM, Altman DG. Comparing methods of measurement: why plotting difference against standard method is misleading. Lancet. 1995; 346(8982):1085–7. [PubMed: 7564793]
17. Martin RF. General deming regression for estimating systematic bias and its confidence interval in method-comparison studies. Clin Chem. 2000; 46(1):100–4. [PubMed: 10620577]
18. Bossuyt PM, Reitsma JB, Linnet K, Moons KG. Beyond diagnostic accuracy: the clinical utility of diagnostic tests. Clin Chem. 2012; 58(12):1636–43. DOI: 10.1373/clinchem.2012.182576 [PubMed: 22730450]
19. Sanchez-Garcia S, Garcia-Pena C, Duque-Lopez MX, Juarez-Cedillo T, Cortes-Nunez AR, Reyes-Beaman S. Anthropometric measures and nutritional status in a healthy elderly population. BMC Public Health. 2007; 7:2.doi: 10.1186/1471-2458-7-2 [PubMed: 17201919]
20. Guigoz Y, Vellas B, Garry PJ. Assessing the nutritional status of the elderly: The Mini Nutritional Assessment as part of the geriatric evaluation. Nutr Rev. 1996; 54(1 Pt 2):S59–65.
21. Forsmo S, Hvam HM, Rea ML, Lilleeng SE, Schei B, Langhammer A. Height loss, forearm bone density and bone loss in menopausal women: a 15-year prospective study. The Nord-Trondelag Health Study, Norway. Osteoporos Int. 2007; 18(9):1261–9. DOI: 10.1007/s00198-007-0369-1 [PubMed: 17387421]
22. Roubenoff R, Wilson PW. Advantage of knee height over height as an index of stature in expression of body composition in adults. Am J Clin Nutr. 1993; 57(5):609–13. [PubMed: 8480674]
23. Komar B, Schwingshackl L, Hoffmann G. Effects of leucine-rich protein supplements on anthropometric parameter and muscle strength in the elderly: a systematic review and meta-analysis. J Nutr Health Aging. 2015; 19(4):437–46. DOI: 10.1007/s12603-014-0559-4 [PubMed: 25809808]
24. Huo YR, Suriyaarachchi P, Gomez F, Curcio CL, Boersma D, Gunawardene P, et al. Comprehensive nutritional status in sarco-osteoporotic older fallers. J Nutr Health Aging. 2015; 19(4):474–80. DOI: 10.1007/s12603-014-0543-z [PubMed: 25809813]
25. Arango-Lopera VE, Arroyo P, Gutiérrez-Robledo LM, Pérez-Zepeda MU, Cesari M. Mortality as an adverse outcome of sarcopenia. J Nutr Health Aging. 2013; 17(3):259–62. DOI: 10.1007/s12603-012-0434-0 [PubMed: 23459979]
26. Bunout D, Barrera G, de la Maza MP, Leiva L, Gattas V, Hirsch S. Height reduction, determined using knee height measurement as a risk factor or predictive sign for osteoporosis in elderly women. Nutrition. 2007; 23(11–12):794–7. DOI: 10.1016/j.nut.2007.08.012 [PubMed: 17936193]
27. Masunari N, Fujiwara S, Nakata Y, Nakashima E, Nakamura T. Historical height loss, vertebral deformity, and health-related quality of life in Hiroshima cohort study. Osteoporos Int. 2007; 18(11):1493–9. DOI: 10.1007/s00198-007-0392-2 [PubMed: 17541811]

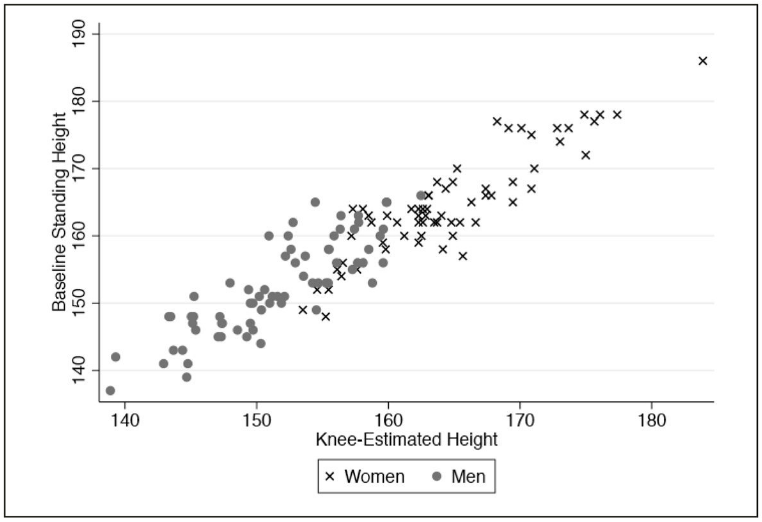
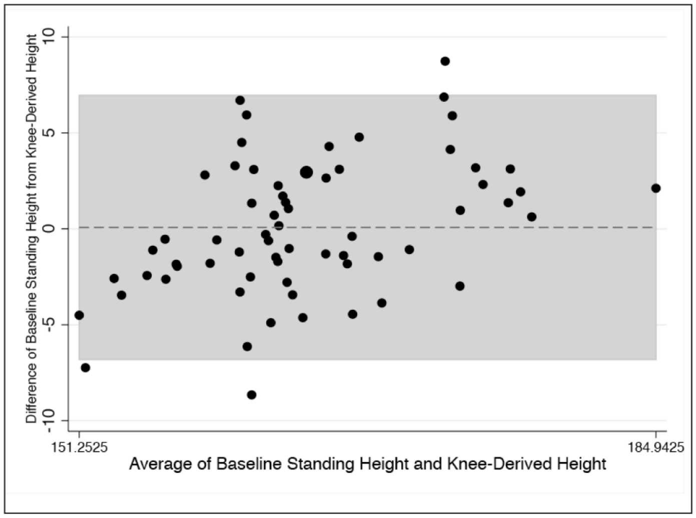


Figure 1.
Scatter Plot Comparing Current Knee-Estimated Height with Baseline Standing Height Stratified by Sex

a)



b)

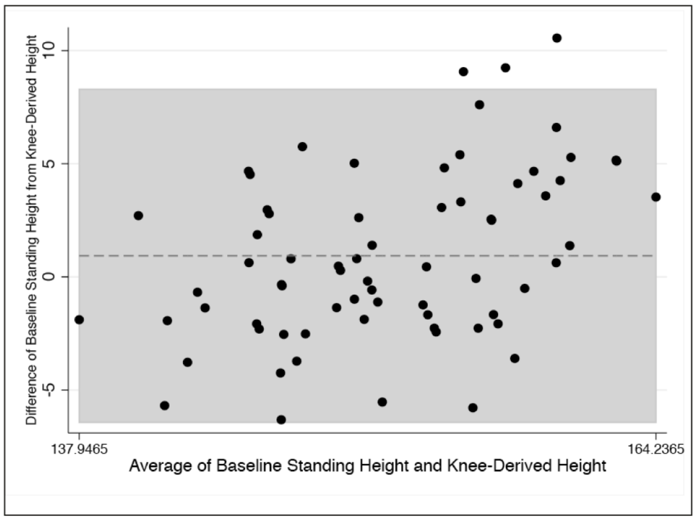


Figure 2.

Bland-Altman Plot of the Difference of Measurements (y-axis) with the Average of Measurements (x-axis) * a) Men b) Women

* Gray area corresponds to 95% confidence intervals of the difference of the measurements

Table 1

General Characteristics of the Population

Measurements	TOTAL	Men (n=66)	Women (n=70)
Age, mean (SD)	60 (7.32)	59.72 (7.47)	60.1 (7.05)
Baseline SH, mean (SD)	157.7 (9.6)	164.53 (7.76)	152.5 (6.97)
Current SH *, mean (SD)	154.7 (9.8)	162.06 (7.97)	149.05 (6.29)
KeH *, mean (SD)	157.9 (8.1)	164.45 (6.32)	151.56 (5.43)

SH= standing height in centimeters, KeH= knee-estimated height in centimeters;

*Current SH and KeH were simultaneously measured eleven years apart from the baseline SH