VALIDATION OF PREDICTIVE EQUATION FOR HEIGHT USING DEMI-SPAN AMONG UNIVERSITI SULTAN ZAINAL ABIDIN STAFF

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ABSTRACT

Demi-span measurement is a method used to estimate height of an individual, especially for those whose height cannot be directly measured. Height is a crucial parameter that is needed to determine other parameters that help in the assessment of one's nutritional status, such as body mass index (BMI). Therefore, this study was conducted to validate the equation for demi-span measurement proposed by Ngoh et al. (2012). This cross-sectional study involved 118 employees of Universiti Sultan Zainal Abidin (UniSZA), Kuala Nerus, Terengganu, Malaysia, who were in the age group of 30-55 years. Weight, height, and demi-span were measured using the standard procedures. The results showed that adult anthropometrics differed on the basis of gender ($p < 0.001$) and age ($p < 0.05$). The height calculated from the equations and the measured height showed consistent agreement and similarity ($r = 0.944$ and $r = 0.949$, respectively). The calculated height led to a BMI estimate that was close to the actual BMI ($r = 0.997$ and $r = 0.996$, respectively) calculated from the measured height. In conclusion, the demi-span equation showed good reliability and was suitable to estimate height and BMI of adult individuals in Malaysia.

Keywords: Validation, Demi-span, Height, UniSZA, Body Mass Index

INTRODUCTION

Anthropometric measurements, such as height, are important for assessing nutritional status indicators, such as body mass index (BMI), basal metabolic rate (BMR) (Sabounchi et al., 2013), basal energy expenditure (Harris & Benedict, 1918), and creatinine height index (Walser, 1987). Due to the importance of height measurement, appropriate methods should be employed to accurately measure height. It may not be always possible to stand upright for height measurement, and in such cases, other methods, such as indirect height estimation using equations and formulae, are required to measure the height.

Previously, researchers have developed various equations for height estimation on the basis of body parameters, such as knee height (Chumlea et al., 1985; Chumpathat et al., 2016; Silva & Figueira, 2016), arm span (Supare et al., 2015), forearm (Mitchell & Lipschitz, 1982), and demi-span (Bassey, 1986; Hirani et al., 2010), for the adults, elderly, and those who are

unable to stand. Equations to estimate the height of older adults are essential as it is difficult to directly measure their height owing to the changes in their body posture, loss of height in the vertebrae, kyphoscoliosis, and arthritis (Hirani et al., 2010). In Malaysia, some researchers have found that the arm-span is significantly associated with the standing height in elderly people as compared to the rest of the body parameters (Shahar & Ng, 2003).

However, only a limited number of studies demonstrate the use of demi-span among Malaysians to derive a height predictive equation. This study was conducted to validate an equation previously developed by Ngoh et al. (2012) and determine if this equation can yield a good agreement between the standing height and the predicted height among the adult population.

The equations developed by Ngoh et al. (2012) are stated below:
1) Men: Height (cm) = 67.51 + (1.29 × demi-span) – (0.12 × age) + 4.13
2) Women: Height (cm) = 67.51 + (1.29 × demi-span) – (0.12 × age)

In order to validate these equations among the adults, the standing height was used instead of the sitting height, since the former is the gold standard.

MATERIALS AND METHODS

Study design and patient recruitment

In this cross-sectional study, we recruited the employees of Universiti Sultan Zainal Abidin (UniSZA), Kuala Nerus, Terengganu, Malaysia. This study was approved by the UniSZA Ethics Committee (UniSZA/C/2UHREC/2018/628-2(48)).

The inclusion criteria included age within 30–55 years, ability to stand upright, and employee of UniSZA. Those who were pregnant, wheelchair-bound, and/or having any difficulty in standing upright were excluded.

Measurement and analysis

Anthropometric measurements included weight (kg), height (cm), demi-span (cm), and BMI (kg/m^2). The body weight of participants (to the nearest 0.1 kg) was measured using a Seca Clara digital bathroom weight scale (Seca 803, Germany) with light clothing and without shoes.

The standing height measurement (to the nearest 0.1 cm) was carried out using a portable stadiometer (Seca 213, Germany) without shoes. Meanwhile, demi-span was measured using a measuring tape. The height and weight measurements were used to calculate the BMI (in kg/m^2) of the participants. The World Health Organization (WHO) criteria on BMI were employed to classify participants as underweight (BMI ≤ 18.5 kg/m^2), healthy weight (BMI 18.5–24.9 kg/m^2), overweight (BMI 25.0–29.9 kg/m^2), and obese (BMI ≥ 30.0 kg/m^2) (WHO, 1995).

Demi-span was measured (to the nearest 0.1 cm) using a mini measuring tape (Germany). The participants were asked to stand upright with their backs against a wall to provide support. The left arm was horizontally abducted in neutral flexion, while the wrist was in neutral rotation (Hirani et al., 2010). The demi-span measurement was taken from the midpoint of the sternal notch to the finger root (between middle and ring fingers) along the outstretched arm. The participants were then asked to stand erect with their backs against a wall to provide support.

Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) software for Windows, version 20.0. Normality of data distribution was evaluated using the Kolmogorov-Smirnov test. Descriptive statistics was performed for sociodemographic characteristics and anthropometric measurements. An independent t test, which is the parametric test in this study, was used to measure the differences in the values of height, weight, demi-span, and BMI measurement using the predictive equation for the two genders.

Pearson's correlation coefficient (r) was used to examine the association between height, demi-span, and age. The relationship between height and demi-span was determined by simple linear regression. In order to examine the relationship between height and demi-span as well as between height and age, separate scatter plots for men and women were created using the height plotted on the Y-axis, while age and demi-span were plotted on X-axis. Pearson's correlation coefficient was also used to determine the agreement between the standing height and the predicted height from the equation.

The agreement of the standing height measured was compared with the predicted height from the equation and evaluated using the intra-class correlation coefficient (ICC) analysis. Based on the 95% confident interval of the ICC estimate, values less than 0.5, between 0.5 and 0.75, between 0.75 and 0.9, and greater than 0.90 are indicative of poor, moderate, good, and excellent reliabilities, respectively (Koo & Li, 2016).

RESULTS

The sample consisted of 121 Malaysian adults, of whom 45 were men (38.1%) and 73 were women (61.9%). All the participants were Malays (100%), and their ages ranged from 30 to 55 years. The mean (SD) age was 38.1 (7.3) years for men and 36.8 (7.2) years for women. For men, the mean height was 167.8 (5.7) cm and the mean demi-span was 79.3 (3.8) cm. For women, the mean height was 155.8 (5.9) cm and the mean demi-span was 72.3 (3.7) cm.

Gender differences in the anthropometric characteristics are shown in Table 1. With regard to gender comparisons, the independent t test revealed that weight, height, and demi-span were significantly greater in men ($p < 0.001$), whereas there was no significant difference in BMI between men and women ($p = 0.538$). Based on one-way ANOVA Tukey's post-hoc test, there was a significant difference in height measurement between the males' age groups of 40–44 years and 50–55 years. There was also a significant difference in the predicted height between men in the age groups of 30–34 years and 50–55 years. Meanwhile, there was no significant difference in anthropometric parameters between women of all age groups.

Table 1: Variation in anthropometric characteristics of adults on the basis of gender.

Variables	**Men (n = 45)**	**Women (n = 73)**	***p*-value***
	Mean (SD)	**Mean (SD)**	
Weight (kg)	76.9 (15.8)	65.0 (14.2)	0.000**
$Height_{(standing)}$ (cm)	167.8 (5.7)	155.8 (5.9)	0.000**
BMI (kg/m^2)	27.3 (5.2)	26.8 (5.1)	0.538
Demi-span (cm)	79.3 (3.8)	72.3 (3.7)	0.000**
[a.] $Height_{(demi-span)}$	169.1 (5.3)	157.0 (5.3)	0.000**
[b.] $BMI_{(new)}$	26.9 (5.1)	26.4 (5.1)	0.539

*Independent t test, significant value was p < 0.05. **Significant difference between men and women.

[a.]Height$_{(demi-span)}$ is measured using the formula:

Men= 67.51 + (1.29 × demi-span) – (0.12 × age) + 4.13

Women= 67.51 + (1.29 × demi-span) – (0.12 × age)
[b.]BMI$_{(new)}$ was measured using the height$_{(demi-span)}$.

The coefficients of variation (CV) for height and demi-span measurements among the adult population were 5.1% and 6.5%, respectively. The CV for height was 5%, which was favourable where the relative variability was very small, whereas the CV for demi-span was slightly higher but close to 5% and still acceptable since it was less than 10% (Ngoh et al., 2012). The results are presented in Table 2.

Table 2: Coefficients of variation for height and demi-span measurements.

Variables	N	Mean (SD)	CV (%)
Height (cm)	118	160.4 (8.2)	5.1
Demi-span (cm)	118	75.2 (4.9)	6.5

Pearson's correlation analyses revealed that there was a strong and positive association between height and demi-span of both males and females (r = 0.915 and r = 0.929, respectively). However, age was weakly and negatively associated with height and demi-span of men and women (Table 3). An examination of scatter plots and regression lines showed that there was a linear relationship between height and demi-span.

Table 3: Correlation coefficients of the variables based on the gender.

Variables	Correlation coefficient (r)		
	Men (N = 45)	Women (N = 73)	All (N = 118)
Height and demi-span	0.915**	0.929**	0.915**
Height and age	-0.282	-0.186	-0.061
Demi-span and age	-0.164	-0.154	-0.164

Data were analysed using Pearson's product-moment correlation; significant at p < 0.05 (2-tailed); **p<0.001

ICC revealed that the mean differences between standing height and predicted height were not significant for either gender. The p-values of ICC indicated that there was a significant difference between the obtained intra-class correlation with the zero value of correlation (no correlation) (Table 4). Meanwhile, the ICC value showed that there was an excellent agreement between the standing height and the predicted height of men and women (0.944 and 0.949, respectively).

ICC also showed an excellent agreement between the BMIs used to measure height (BMI) and BMI used to measure demi-span and predicted height (BMI$_{new}$), as shown in Table 4. The mean difference between these two measurements was not significant and almost similar, since the correlation values approached one both in men and women (0.997 and 0.996, respectively).

Table 4*:* Level of agreement between height and BMI based on intraclass correlation.

	Mean (SD)	Mean difference[a] (SD)	Intraclass correlation[b] [CI[c]]	*p*-value
Men (n = 45)				
Height$_{(standing)}$	168.8 (5.7)			
Height$_{(demi-span)}$	169.1 (5.3)	-1.3 (2.3)	0.944* [0.740, 0.950]	p < 0.001**
BMI	27.3 (5.2)			
BMI$_{(new)}$	26.8 (5.1)	0.4 (0.7)	0.997* [0.965, 0.994]	p < 0.001**
Women (n = 73)				
Height$_{(standing)}$	155.8 (5.9)			
Height$_{(demi-span)}$	157.0 (5.3)	-1.2 (2.2)	0.949* [0.886, 0.974]	p < 0.001**
BMI	26.9 (5.0)			
BMI$_{(new)}$	26.4 (5.1)	0.4 (0.8)	0.996* [0.992, 0.982]	p < 0.001**

[a.] Measured height minus predicted height; positive values denote underestimation, negative values denote overestimation

[b.] Intraclass correlation coefficient ≤0.5 = poor, 0.5–0.75 = moderate, 0.75–0.9 = good, and >0.90 are indicative of excellent reliability.

[c.] Confidence interval

* Excellent agreement.

**Significant correlation, $p < 0.001$

DISCUSSION

This study showed that demi-span measurement can be used in population studies to derive the height among adult population when other anthropometric indices, such as BMI, are measured to estimate the nutritional status and to evaluate the relationship between BMI and other diseases. It is undeniable that height is one of the important parameters used to estimate BMR, energy requirement, and creatinine height index of the patients.

Even though the equation used in this study was derived for adults and senior citizens based on Shahar and Ng's (2003) work, it failed to yield good agreement among the elderly and showed a good reliability among the adult population instead. Ngoh et al. (2012) further modified Shahar and Ng's (2003) equation, but even they failed to validate it among the elderly people. This finding may be attributed to the decline in the physical stature of senior citizens, which is in agreement with the findings of Weinbrener et al. (2006), who showed that height, demi-span, weight, and BMI decreased with increasing age in both genders for those with age >65 years. Hirani et al. (2016) devised new equations for people with age ≥65 years. However, they showed prediction of a larger height from the demi-span equation than the actual height measured in both men and women.

This finding was supported by Fernihough and McGovern (2015) who showed that there is approximately 2–4 cm reduction in the height of those with age > 60 years. Nevertheless, this study failed to identify the consistent predictors of physical stature decline at individual level. In comparison with the study done by Huang et al. (2013), it is shown that about 1.5 cm decrease in the height of male and female was equal to the decrease in the height of 1.3 cm for each year after the age of 60 years.

Demi-span is one of the anthropometric parameters that have been proven to be convenient because it requires no specialised equipment and can be measured quickly (Lahner et al., 2016). Hirani et al. (2016) also showed a close agreement between measured

height and newly derived height from demi-span equation in adult population, indicating that the demi-span equation can be used as a proxy for height when direct height measurement is not possible.

CONCLUSION

This study revealed that the height predicted by the equation showed an excellent agreement with the manually measured height. The BMI calculated by the height measured using the equation was also in excellent agreement with the BMI calculated using the manually measured height. Therefore, the equation proposed by Ngoh et al. (2012) can be used to estimate the height among Malaysian adults, especially for those who have mobility impairment, are bedridden, and/or with amputated legs.

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