Original Article

Estimating geriatric patient's body weight using the knee height caliper and mid-arm circumference in Hong Kong Chinese

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The use of the knee height caliper is a convenient way to estimate a patient's body weight. However, the equation devised to estimate an individual's body weight was specifically designed for Caucasians and Blacks. Therefore, this study is to assess the suitability of the knee height caliper among Chinese geriatric patients residing in Hong Kong. Over a six-month period, all geriatric patients from an acute care hospital and private nursing home in the Kwun Tong were recruited into the study. Only patients/residents that were considered unstable with ascites; low blood pressure; on cardiac monitors or had respiratory difficulties were excluded. Measurements from the knee height caliper and mid-arm muscle circumference of the patients were necessary for estimating their body weights. The actual body weights measured with calibrated bed, chair or portable scales was compared with the calculated body weights from the equation. A comparison of the mean and linear regression was performed for analysis of the results. A total of 300 geriatric patients (200 females and 100 males) were recruited. The mean MAC and knee height results were as follows: 25.1 cm (SD 3.9) for females and 26.2 cm (SD 3.2) for males; and 45.75 cm (SD 2.09) for females and 48.98 cm (SD 2.09) for males respectively. The mean difference among the male group was 0.4222 (95% CI: -0.54, 1.39) with a mean estimated body weight of 58.1 kg (SD 10.1) and a mean actual body weight of 57.7 kg (SD 9.9). The mean difference among the female group was 2.9649 (95% CI: 2.30, 3.63) with a mean estimated body weight of 51.6 kg (SD 10.9) and a mean actual body weight of 48.6 kg (SD 10.1). A new equation devised from the data is as follows: Chinese males (over 60 years of age) (R-square -0.81) Weight = [knee height (cm) x 0.928 + mid-arm circumference (cm) x 2.508 – age (years) x 0.144] - 42.543 $\pm$ 9.9kg of actual weight for 95% of Chinese males; Chinese females (over 60 years of age) (R-square - 0.82) Weight (kg) = [knee height (cm) x 0.826 + mid-arm circumference (cm) x 2.116 – age (years) x 0.133] – 31.486 $\pm$ 10.1kg of actual weight for 95% of Chinese females. The results showed that the mean estimated body weight calculated from the knee height equation (for Caucasians) was significantly larger than the mean actual body weight for the Chinese subjects. This study suggests that the knee height caliper is a useful tool for estimating the body weights. However, a multi-center study is necessary to validate the new equation for the elderly Chinese population.

Key Words: knee height caliper, body weight, mid-arm muscle circumference, Hong Kong Chinese.

Introduction

Malnutrition is common amongst the elderly living in nursing homes (NH).[1,2] There are documented findings such as one by Lee *et al*., that show a high prevalence (21.6%) of elderly persons living in institutions to have protein energy malnutrition.[3] This figure could be higher since malnutrition was defined by a BMI level of 18.5 or less. Therefore, if this author had considered using a BMI level of 20 or less to define malnutrition then the prevalence would most likely be higher. Similar occurrences are also observed in hospitals where there are a lot patients admitted from NH. At the United Christian Hospital, approximately 100 patients admitted to hospital (from NH) in the fall of 1998 were assessed for their nutritional status. Patients' had an average BMI of 17 and 64% of all patients assessed had abnormal skin-fold thickness (<10%). These findings are of concern since there are approximately 45,000 elderly persons living in Hong Kong NH according to the annual report by the Social Welfare Department. With an estimated hospital cost of $3,300 (Hong Kong dollars) per day for each person, the cost to patient and community can be high. In addition,

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poor nutritional status is associated with increased risk of sepsis and thereby a longer hospital stay.[4,5] In order to address this ever-growing problem, the Hospital Authority initiated the Allied Health Project (AHP) as a way to help. The aim of the AHP was to facilitate safe and early discharge of private nursing home (PNH) residents from the hospital back to the community. One of the Dietetic Department's goals is early detection of malnourished residents and subsequent treatment in order to prevent or reduce hospital admission.

Anthropometric measurement is one of the easiest and cheapest forms of nutritional assessment. However, finding a quick and accurate method to assess and screen the nutritional status of the patients is a problem. Even the most basic measure of BMI may be impractical since many PNH do not possess bathroom scales let alone a bed or chair scale. The knee height caliper seemed like a practical solution in estimating body weight since it was lightweight, portable, and required only one person to use. However, existing equations devised to estimate an individual's body weight (using the knee height caliper) were designed specifically for Caucasians and Blacks. The present study was devised to assess the suitability of the knee height caliper in estimating body weight among Chinese elderly persons in Hong Kong.

Method

Over a six-month period, all geriatric patients in an acute care hospital and PNH residents in the Kuhn Tong area were included into the study. The following patients or residents were excluded from the study: if considered to be unstable with ascites, if they had low blood pressure, were on cardiac monitors or had respiratory difficulties; if they refused measurements; if they had amputations or missing limbs or if they were under 60 years of age. The examiners compared techniques with trial measurements on ten subjects in order to minimise inter-rater variability. Each examiner followed the procedures set out in the instruction manual of the knee height caliper (Ross Laboratory, OH, USA) for the estimation of body weight. Mid-arm circumference (MAC) measurements were also taken according to the Manual of Clinical Dietetics[6] since the MAC is a required measurement for the estimation of the patient's body weight. The patient either standing or lying had their sleeves rolled up above the shoulder and their right arm bent to 90 degrees. The midpoint between the accordion and the colcannon was marked with a pen. The MAC was measured with the measuring tape snug but not compressed to the flesh. Three measurements were taken

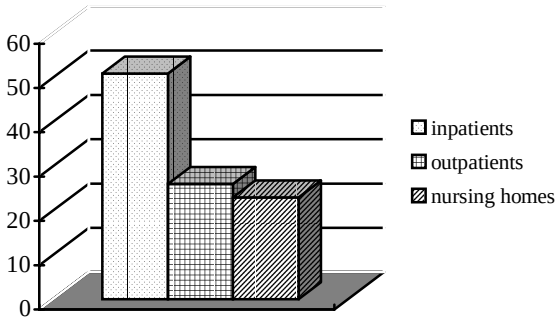

Figure 1. Percentage of subjects from inpatient, outpatient and nursing homes

to the nearest decimal point and then the average calculated to be used in the knee height caliper equation. All bed, chair and portable scales used to measure the actual body weights of the subjects were calibrated to the nearest 0.1 kg before usage. In-hospital patients were measured in their hospital gown with emptied drains or foleys (if any) and then the weights of their gown, drains or foley were subtracted from the actual body weight measurement. Patients assessed in the outpatient setting and in the NH were measured in their street clothes. But these patients were asked to remove all coats and sweaters before weighing. An estimation of the weight of the street clothes was made before being subtracted from the actual body weight measurement. The estimated body weights as calculated by the equation given for Caucasian males or females (Table 1) was then compared to the actual body weights of these subjects. This study did not limit the age of the subject to 80 years as it did for the Caucasian equation since many of the patients who would benefit most from the use of the knee height caliper are usually older than 80 years. A total of 300 subjects were recruited into the study. Comparison of the mean and linear regression was performed for analysis of the results.

Results

A total of 200 females and 100 males were included into the study -51% were inpatient, 26% were outpatient while 23% were from nursing homes (Fig. 1). Their age distribution was as follows: 14% 60-69 years, 42% 70-79 years, 31% 80-89 years, 12% 90-99 years, and 1% 100-109 years (Fig. 2). The mean MAC and knee height results were as follows: 25.1 cm (SD 3.9) for females and 26.2 cm (SD 3.2) for males; and 45.75 cm (SD 2.09) for females and 48.98 cm (SD 2.09) for males respectively. The mean

Table 1. Equation for estimating weight from knee height (Caucasians)

White Males 60 to 80 years	Weight (kg) = knee height x 1.10 + MAC (cm) x 3.07 – 75.81
White Females 60 to 80 years	Weight (kg) = knee height x 1.01 + MAC (cm) x 2.81 – 66.04

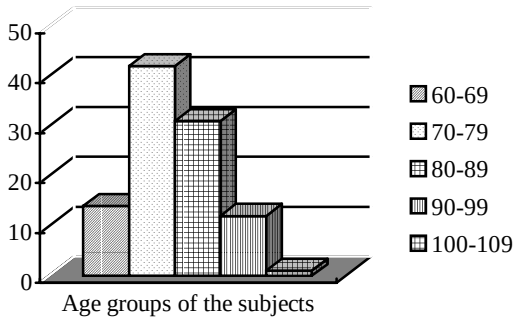

Figure 2. The age distribution of the subjects

difference among the male groups was 0.4222 (95% CI: -0.54, 1.39) with a mean estimated body weight of 58.1 kg (SD 10.1) (Table 2) and a mean actual body weight of 57.7 kg (SD 9.9). The mean difference among the female group was 2.9649 (95% CI: 2.30,3.63) (Table 2) with a mean estimated body weight of 51.6 kg (SD 10.9) and a mean actual body weight of 48.6 kg (SD 10.1). A new equation was devised for both males and females using the data collected and by linear regression model for males (Fig. 3) and females (Fig. 4). R-square for the new equation is 0.81 for male and 0.82 for female.

Discussion

Malnutrition among the elderly patients is an ever-growing problem. Today's population is living longer[6] and with the worsening economic condition, some families may be forced to place their aging parents or relatives in NH. Therefore, early identification of malnourished seniors must be performed in order to lessen the strain on the health care system.[7]

Several studies have shown that the knee height caliper is a useful, reliable and acceptable tool in estimating the body heights of elderly patients[8] but few have assessed the suitability of the knee height caliper in estimating body weight. However, adjustments to the Caucasian equation is necessary since this study showed that the mean estimated body weight calculated from knee height

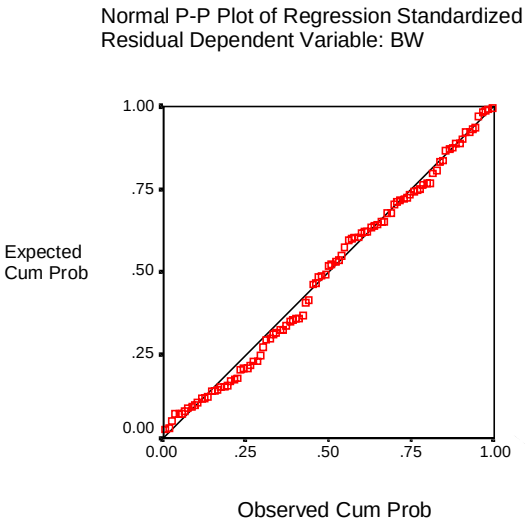

Figure 3. Linear regression model of the new equation for male subjects

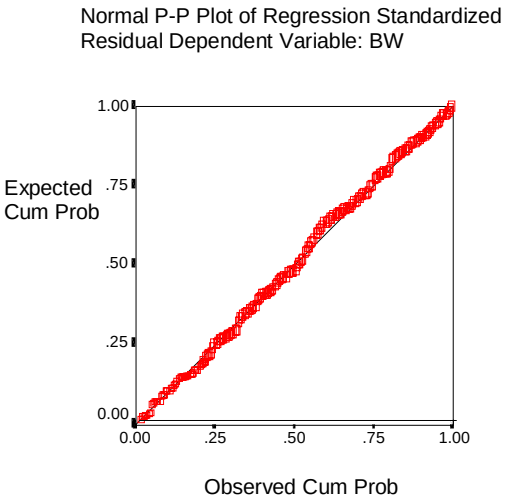

Figure 4. Linear regression model of the new equation for female subjects

Table 2. The mean difference among the male and female groups.

	Mean difference	Mean estimated body weight	Mean actual body weight
Male group	0.4222 (95% CI: -0.54, 1.39)	58.1 kg (SD 10.1)	57.7 kg (SD 9.9)
Female group	2.9649 (95% CI: 2.30,3.63)	51.6 kg (SD 10.9)	48.6 kg (SD 10.1).

Table 3. New equations derived from the 300 Chinese elderly subjects

Chinese males (over 60 years of age) (R-square -0.81) Weight = [knee height (cm) x 0.928 + mid-arm circumference (cm) x 2.508 – age (years) x 0.144] - 42.543 ± 9.9kg of actual weight for 95% of Chinese males
Chinese females (over 60 years of age) (R-square - 0.82) Weight (kg) = [knee height (cm) x 0.826 + mid-arm circumference (cm) x 2.116 – age(years) x 0.133] – 31.486 ± 10.1kg of actual weight for 95% of Chinese females

equation of white subjects was significantly larger than the mean actual body weight of Chinese subjects. Several factors that include race and age play a part in the large difference. Many studies have shown that there are physical differences between Asians and Caucasians.[9-11] One such study by Wang et al., noted that Asians have a tendency to have more subcutaneous fat (especially upper-body) than their Caucasian counterparts. As a result, this higher upper body subcutaneous body fat will give a larger MAC value for Asians[12] and a resultant higher estimation of body weight.

Another factor that had an impact on our results is the age of the subjects. This study did not limit the age of its subjects to 80 years as is the case for the Caucasian equation. A main reason is that the elderly patients that would benefit most from the use of the knee height caliper for estimating body weight are greater than 80 years of age. Decreased motility and leg strictures are increased with age which was also observed in our study. Over 43% of our total subjects were greater than 80 years of age. In addition, there is an increase in body fat in relation to muscle mass as people age[13] and therefore may affect final calculation of body weight. There might be a false indication of higher body weight with high MAC, but since body fat is lighter than muscle mass then the estimated body weight is incorrect. Therefore, the age factor must be included into the equation to account for this phenomenon.

This study has shown that the knee height caliper is a useful and feasible tool for estimating body weight since there are few tools available in the market place that do not require the patient to move (such as the frail and bed-ridden patients) or require extensive finances to purchase (such as a bed scale). In addition, several studies have shown that the measurement of the knee height is independent of age.[14,15] This is an important aspect when assessing the nutritional status of a person over a period of time. Even though the caliper is a valuable tool, this study does address the need for a knee height equation for Chinese subjects with the obvious racial difference. The new equation devised from this study factors in age, race and sex, which are important for improved accuracy in its estimation of body weight (Table 3). Therefore, a multi-center study is necessary to validate the new equation for the elderly Chinese population over 60 years of age.

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