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Determination of Calf Circumference Cut-Off Values for Malaysian Elderly and its Predictive Value in Assessing Risk of Malnutrition

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ABSTRACT

Introduction: Malnutrition is a growing problem but quite often under-recognised in elderly people. Calf circumference (CC) is a simple measurement that can be used to identify elderly people who are at high risk of malnutrition; however, a population-specific cut-off point must be developed. Therefore, this study aimed to determine suitable cut-off points and evaluate the predictive value of the CC cut-off point for elderly Malaysians. **Methods:** A total of 820 persons comprising 433 men and 387 women were recruited as subjects. The mean age was 69.0 ± 6.8 and ranged between 60 to 97 years. Data were collected from Sabak Bernam, Selangor; Kuala Pilah, Negeri Sembilan; Pasir Mas, Kelantan, and Kodiang, Kedah. A linear regression analysis with the z-score procedure by gender was used to derive the CC prediction equations. **Results:** The CC cut-off points for men and women at risk of malnutrition were 30.1 cm and 27.3 cm, respectively. The final predictive CC equations for men was CC (cm) = 3.69 (z score) + 33.81, R2 = 1 and CC (cm) = 0.7103 (BMI) + 18.54, R^2 = 1; and for women, CC (cm) = 4.31 (z score) + 31.63, R^2 = 1 and CC (cm) = 0.6698(BMI) + 16.847, R^2 = 1. Based on these equations, using the z-score equal to negative 1 for men (BMI 16.30 kg/m^2) and women (BMI 15.64 kg/m^2), the mean of the predictive value of the CC cut-off point was 32.0 ± 4.2 cm in men and 30.5 ± 4.6 cm in women. **Conclusion:** It is suggested that these cut-off points be used to screen elderly individuals who are at risk of malnutrition. Further studies should be undertaken to further verify the application of the findings of this study.

Key words: Calf circumference, cut-off point, Malaysian elderly, malnutrition, nutritional risk

INTRODUCTION

Based on year 2005 statistics in Malaysia, it is estimated that the percentage of the elderly (age above 65) is 4.6% compared to 3.9% in 2000, and by the year 2050, the proportion will increase to 21% (7.9 million), which is almost double the number in 20 years' time (Malaysian Department of Statistics, 2005). Malnutrition is a common problem among older people due to physi-

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ological changes with aging, occurrence of age-related chronic diseases and psychosocial and health problems that would influence food purchasing, preparation, and intake. Malnutrition in elderly people is often accompanied by anorexia, impaired immune function and accelerated muscle loss. The prevalence of malnutrition in Malaysia ranges between 5 to 40% among the non-institutionalised elderly (Shahar *et al*., 2007), 8 to 71% of the hospitalised elderly (Sakinah *et al*., 2012) and 2 to 63% in nursing homes (Visvanathan *et al*., 2005). However, malnutrition is often unrecognised due to the technical difficulties of diagnosing malnutrition.

Calf circumference (CC) is a simple, convenient and non-invasive measurement recommended by the World Health Organization (WHO) (WHO, 1995) as a tool to assess the risk of malnutrition in elderly individuals. It is an indicator of body muscle mass and subcutaneous fat (Bonnefoy *et al*., 2002). CC has the potential to serve as a malnutrition indicator (Vellas *et al*., 2006) as it correlates closely with the stored body protein and an indicator for fat-free mass (Chumlea & Sun, 2003). However, a population-based specific cut-off point or reference value has to be developed to ensure its sensitivity and specificity in evaluating the nutritional risks among elderly people. The Z-score is a simple method that can be used to describe the reference population, its comparison and also the suggested statistics for nutritional assessment. The Z-score or standard deviation (SD) is defined as the difference of individual value to the reference population median of the same age or height, divided by the standard deviation of the reference population (WHO, 1995). Studies done among the French elderly determined 31.0 cm as a cut-off point to identify those who are at risk of malnutrition. This value has been used in the Mini Nutritional Assessment (MNA) to screen the elderly in the communities, hospitals, and institutions in Europe (Rolland *et al*., 2003). Whereas, for those hospitalised elderlies in France, a cut-off point of 30.5cm was used as a marker for malnutrition (Bonnefoy *et al*., 2002).

However, there is an obvious difference in the body size between different populations (Chumlea, Guo & Steinbaugh, 1994). This implies that the anthropometric measurements for the Asian population are significantly different from those of the Caucasian population. Considering the anthropometric differences across populations, a recent study attempted to establish a Taiwanese-specific version of the Mini Nutritional Assessment (MNA), suggesting that the population-specific cut-off points for CC in the Taiwanese elderly are 28 cm for men and 25 cm for women (Tsai, Ho & Chang, 2007). Several Taiwanese studies also found that the application of this modified CC cut-off points improved the usefulness of the MNA in the Taiwanese elderly under various life settings (Tsai & Shih, 2009).

As yet, there is no suitable cut-off point for CC being developed for the Malaysian elderly. Thus, this paper aims to determine the population-specific calf circumference cut-off point for the Malaysian elderly and also evaluate its predictive value in assessing the nutritional risk among this age group.

METHODS

Study design and subjects

This is a cross-sectional study on the evaluation of the calf circumference measurement in several cross-sectional studies among older people aged 60 years and above which comprises Cohorts 1 and 2.

Cohort 1

There were 820 rural elderly Malays (28.9% from Negeri Sembilan, 35.6% from Selangor, 18.8% from Kelantan and 16.7% from Kedah) aged 60 years and above involved in Cohort 1. They had no known terminal

and mental illness, nor were they suffering from amputation or a previous history of hip fracture; the sampling method for this cohort has been previously described (Shahar *et al.*, 2007). Data in Cohort 1 was collected from January to June 2000. This study was approved by the Universiti Kebangsaan Malaysia Ethical Committee. Cohort 1 was used to determine the cut-off point for calf circumference. All subjects were measured for calf circumference, body weight, and height.

Cohort 2

Cohort 2 involved 181 hospitalised elderly people aged 65 years and above admitted to the geriatric ward at University Malaya Medical Centre between April and August 2003. The study was approved by the Medical Ethical Committee of the UMMC (MEC: 290.12). The majority of the subjects were Malays (37.6%), followed by Chinese (35.9%) and Indians (26.5%)

Cohort 2 was used to evaluate the predictive values of the CC cut-off point in assessing the nutritional risk as measured using anthropometry, biochemical and clinical markers. All subjects were measured for calf circumference, body weight, and height.

Anthropometric parameters

Calf circumference

The measurement of calf circumference was based on the National Health and Nutrition Examination Survey (NHANES) guidelines. Calf circumference was measured using a flexible tape with the subject standing. The loop of the tape was moved up and down the calf to locate the largest diameter on the subject left leg. The tape is-pulled snug around the calf but should not be so tight that the tissue is compressed. The measurement was recorded to the nearest 0.1cm. Successive measurements should agree within 0.5cm and repeated three times.

Body mass index

The weight (kilograms) and height (meters) of functionally independent subjects were measured by the standard method using the pedometer SECA weighing scale and stadiometer.

For the partially dependent subjects, especially in Cohort 2, stature was estimated from the arm span and substituted into the following equations [25]:-

Men: Height =
[0.681 x arm span (cm)] + 47.56
Women: Height =
[0.851 x arm span (cm)] + 18.78

The arm span was measured by a flexible tape.

For the partially dependant subjects in Cohort 2, the weight was calculated by using the predictive formula proposed by Chumlea *et al.* (1994) which includes the measurement of calf circumference (CC), knee height (KH), mid-upper arm circumference (MUAC), and subscapular skinfold (SSF). The predictive equation is as below:

Men: (0.98 x CC) + (1.16 x KH) + (1.73 x MUAC) + (0.37 x SSF) - 81.69
Women: (1.27 x CC) + (0.87 x KH) + (0.98 x MUAC) + (0.4 x SSF) -62.23

The Body Mass Index (BMI) was calculated as weight (kilograms) divided by height (meters) squared. The established malnutrition for BMI is 18.5kg/m^2 and below (WHO, 1998; Winter *et al.*, 2014).

Biochemical indicators

Serum albumin is the indicator used for a biochemical blood test. The cut-off point for albumin measured was set at 35g/L (normal range: 35-55g/L) and defined as malnutrition (Cao, 2002). The blood samples of the subjects were taken within 72 h upon ward admission. Each subject had to fast for 12 h before the blood samples were taken (Ortega *et al.*, 1994). They were not allowed to eat or drink any beverages (except plain water) during fasting.

After completing a 12-h fast, 3 ml of blood sample was initially taken from subject's left arm by a nurse using a 22.5 G syringe and put into a yellow closed gel tube (Vacutainer SST® sterile, 3.5ml) for the serum albumin test. The gel tube is used due to its ability to isolate serum from the whole blood which is vital for the serum albumin analysis. The blood samples in Cohort 1 were analysed at the Chemical Pathology Laboratory, Universiti Kebangsaan Malaysia Medical Centre (UKMMC).

All blood samples in Cohort 2 were sent to the Clinical Diagnostic Laboratory at University Malaya Medical Centre (UMMC) for analysis. The serum albumin test was carried out by using a DADE Dimension® Clinical Chemistry System with the analysis method being 'modified bromocreasol green binding assay'.

Clinical assessment

Subjective Global Assessment (SGA) involves the measurement of subjective and objective aspects of a patient to determine the stage of malnutrition (Baker *et al*., 1987; Bauer, Capra, & Ferguson, 2002). SGA classifies a patient as well-nourished, mildly malnourished or suspected of malnutrition and severely malnourished. This classification is based on the clinician's subjective rating of a patient when taking the medical history and doing the physical examination. The clinician rates each medical history and physical examination parameter as an A, B, or C on the SGA scoring sheet. On the basis of all of these ratings of the parameters, the clinical observer assigns an overall SGA classification which corresponds to his or her subjective opinion of the patient's nutritional status. In general, 60% of the clinician's rating of the patient is based on the results of the medical history and 40% on the physical examination (Kalantar-Zadeh *et al*., 1998).

Statistical analysis

The statistical analysis was performed using SPSS version 11.0 (SPSS Inc., Chicago, IL, USA). The linear regression analysis with the z-score procedure by gender was used to derive the calf circumference prediction equations. The equation can be written as follows:

$$\text{Z-score (or SD score)} = \frac{\text{(observed value) – (reference median)}}{\text{Reference population standard deviation}}$$

In addition, the analyses on the sensitivity, specificity, positive and negative predictive value tests were conducted to evaluate the validity of CC towards BMI, SGA, MUAC, and serum albumin.

RESULTS

Data on Cohort 1 was carried out among the elderly in Sabak Bernam, Selangor (n=292); Kuala Pilah, Negeri Sembilan (n=237); Pasir Mas, Kelantan (n=154), and Kodiang, Kedah (n= 137). The subjects were aged 60 years and above (433 men, 387 women; mean age = 69.0 ± 6.8 years; range: 60 to 97 years).

Cohort 1: Cut-off point for calf circumference (CC)

The linear regression graph for men is shown in Figure 1(a). The final prediction equation for men was CC(cm) = 3.69 (Z score) + 33.81, R^2=1. Figure 1(b) shows the correlation graph for the male subjects where the final prediction is CC (cm) = 0.7103 (BMI) + 18.54, R^2=1. Applying these equations using the Z-score equals to negative 1, the BMI was 16.30 kg/m^2 and the cut-off points for men at risk of undernutrition was 30.1 cm (Table 1). It is noted from Figure 1(c) that CC is positively correlated to BMI in men (r=0.797, p<0.01).

Figure 1(d) shows the linear regression graph for women. The final prediction equation women was CC (cm) = 4.31 (Z score) + 31.63, R2=1. Figure 1(e) shows the correlation graph for female subjects where the final prediction is CC (cm) = 0.6698 (BMI) + 16.85, R2=1. Based on these

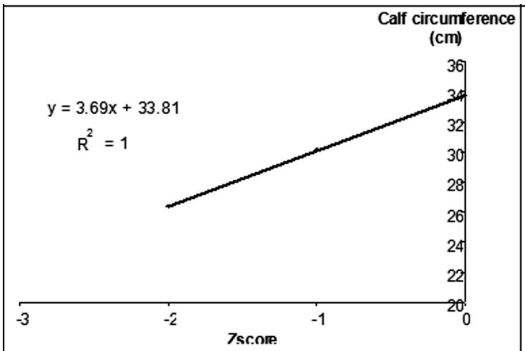

Figure 1(a). Linear regression graph for male subjects

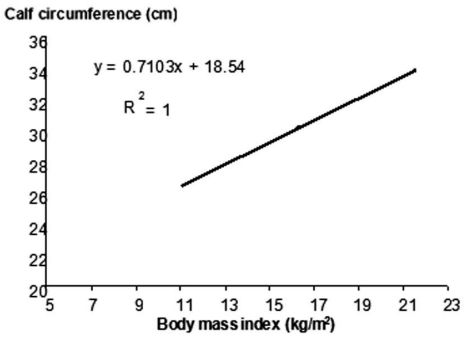

Figure 1(b). Correlation graph for male subjects

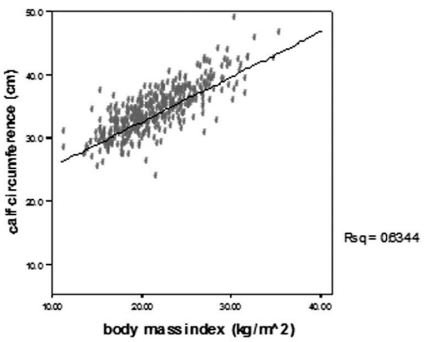

Figure 1(c). Scatterplot of calf circumference of male subjects by BMI

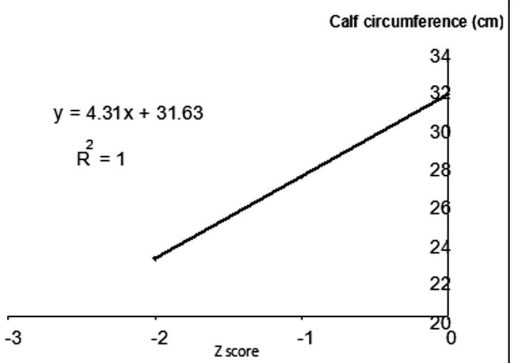

Figure 1(d). Linear regression graph for female subjects

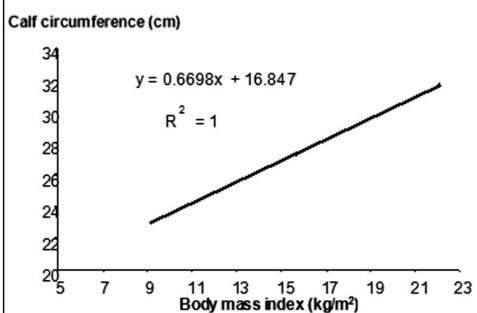

Figure 1(e). Correlation graph for female subjects

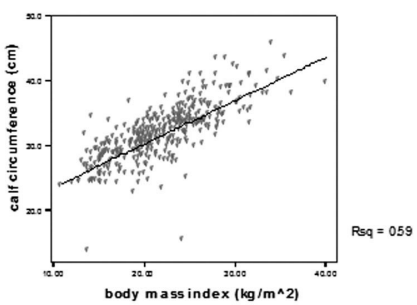

Figure 1(f). Scatter plot of calf circumference of female subjects by BMI

Figure 1. Linear regression, correlation and scatter plot graph of subjects

equations using the Z-score equals to negative 1, the BMI was 15.64 kg/m2 and the cut-off points for women at risk of undernutrition was 27.3 cm (Table 1). As shown in Figure 1(f), CC is positively correlated to BMI in women (r=0.766, p<0.01).

Cohort 2: Predictive value of CC cut-off point for nutritional risk

The mean of CC in Cohort 2 was 32.0 ± 4.2 cm in men and 30.5 ± 4.6 cm in women (Table 1). The prevalence of malnutrition among hospitalised elderly in Cohort 2 as assessed by low CC, i.e. <30.1 cm in men was (n=21) 25.3% and <27.3 cm in women was (n=26) 26.5%. It was found that the mean of the outcome of nutritional parameters was significantly lower in subjects with low CC in hospitalised individuals (Table 2). The sensitivity, specificity and negative predictive values of CC cut-off were the highest in BMI and SGA compared to MUAC and albumin (Table 3).

DISCUSSION

In this study, the cut-off point of CC was determined by using a cohort of apparently healthy rural Malaysian elderly. The severity of the underlying disease may have been milder in the community elderly than those hospitalised. The CC can be used as an indicator for malnutrition (Vellas *et al*., 2006). It has a close relationship with muscle protein and can be used as the indicator of lean body mass (Chumlea & Sun, 2003). Early detection of under-nutrition in an elderly, based on CC assessment, could contribute to prevent its development and consequences (Cuervo *et al.,* 2008). The Z-score analysis, based on WHO standard, is widely used (WHO, 1995) and recommended for determining the cut-off point of malnutrition groups, especially in children.

The CC cut-off point to be classified as malnutrition in this study was <30.1cm (man) and < 27.3cm (woman). There are different references for the CC cut-off point for the elderly in certain countries (European, South America, and Asian country) (Table 4). The CC cut-off points in the European countries and South America are higher compared to the CC cut-off point among the elderly in Malaysia. A similar CC cut-off point was used in both the male and female elderly in these countries. In contrast, different CC values for the cut-off point for the male and female genders are used for the elderly in the Asian countries, including Malaysia. It is noticed that the CC cut-off point in the Taiwanese study is quite similar to that of the CC determined in this study, which is 30.0 cm and 27.0 cm in men and women, respectively (Tsai & Chang, 2011).

Different cut-off points have been used in the MNA to assess the nutritional status of an elderly. MNA is actually a screening tool to identify malnutrition or risk of malnutrition in the elderly, and is considered to be a good standard for determining the nutritional status of the elderly. This tool is one of the most widely used tools to identify the malnourished elderly or individuals at risk of malnutrition. It was developed using data generated from the geriatric patients in the United States and Europe and validated with the clinical data of Caucasian populations 34 (Leandro-Merhi, Aquino, & Camargo, 2011; Tsai & Chang, 2011).

A French researcher had determined 31.0 cm as the CC cut-off point to identify elderly patients who might be at risk of malnutrition and this value has been used in the MNA to screen elderly people in communities, hospitals, and nursing homes in Europe (Rolland *et al*., 2003). A study reported in Brazil used the 32.2cm CC cut-off point for both men and women aged 60 years and older in the MNA (Leandro-Merhi *et al*., 2011). One of their results related to the parameters of CC showed that it is very specific in detecting a well-nourished patient with the specificity being 86.1%. They also claimed that if the CC cut-off value of 32.2 cm was used, there

Table 1. Anthropometric, biological and clinical characteristics of subjects in Cohorts 1 and 2 [expressed as mean ± SD or number (%)]

CC Z score	*CC values (cm) [cut-off points]*		*BMI classification*	*BMI (kg/m2)*	
	Men (n=429)	*Women (n=381)*		*Men (n=429)*	*Women (n=381)*
0	33.81 ± 3.69	31.63 ± 4.49	Normal	21.50	22.07
< - 1.0	30.12	27.32	Chronic Energy Deficiency III	16.30	15.64
< - 2.0	26.43	23.01	Severe malnutrition	11.11	9.20

Parameters	*Cohort 1*		*Cohort 2*	
	Men (n=433)	*Women (n=387)*	*Men (n=83)*	*Women (n=98)*
Age (years)	69.0 ± 6.2		73.4 ± 6.2	
Weight (kg)	(n=429)	(n=383)		
	61.2 ± 12.6	52.3 ± 12.3*	61.7 ± 15.4	51.4 ± 13.8*
Height from armspan (cm)	(n=429)	(n=383)		
	162.0 ± 0.1	150.0 ± 0.1*	161.9 ± 0.1	148.6 ± 0.1*
Body mass index (kg/m2)	(n=429)	(n=383)		
	23.3 ± 4.5	23.3 ± 5.2	23.5 ± 5.5	23.1 ± 5.8
Calf circumference (cm)	(n=429)	(n=381)		
	33.8 ± 3.7	31.6 ± 4.5*	32.0 ± 4.2	30.5 ± 4.6*
MUAC (cm)	(n=429)	(n=381)		
	29.0 ± 4.0	28.9 ± 5.1	27.3 ± 4.5	26.9 ± 4.9
Serum albumin (g/L)	(n=325)	(n=208)		
	43.1 ± 3.3	43.1 ± 3.4	33.1 ± 7.0	33.2 ± 6.3
Prevalence	(n=428)	(n=378)		
- underweight	57 (13.3)	63 (16.7)	13 (15.6)	20 (20.4)
- normal	227 (53.0)	168 (44.4)	37 (44.6)	44 (44.9)
- overweight	107 (25.0)	92 (24.3)	26 (31.3)	20 (20.4)
- obesity	37 (8.7)	55 (14.6)	7 (8.5)	14 (14.3)
Prevalence of malnutrition using Subjective Global Assessment (SGA)	(n=423)	(n=369)		
-normal	167 (39.5)	200 (54.2)	17 (20.5)	14 (14.3)
-mild to moderate	228 (53.9)	122 (33.1)	57 (68.7)	72 (73.5)
-severe	28 (6.6)	47 (12.7)	9 (10.8)	12 (12.2)

*p<0.05, significant using independent sample t-test.

Table 2. Anthropometric and biological characteristics based on calf circumference (CC) group in Cohort 2 [presented as mean ± SD]

Parameter	*CC group*	*Men 1=(n=21) 2=(n=62)*			*Women 1=(n=26) 2=(n=72)*		
		Mean	*SD*	*p value*	*Mean*	*SD*	*p value*
BMI (kg/m2)	1	17.90	3.33	<0.05	17.04	3.39	<0.05
	2	25.52	4.69		25.16	4.96	
MUAC (cm)	1	23.06	2.95	<0.05	21.99	2.82	<0.05
	2	28.8	3.98		28.63	4.23	
Serum albumin (g/L)	1	32.05	7.27	<0.05	31.28	6.86	<0.05
	2	33.39	6.96		33.81	6.04	

Notes: CC group: group 1 CC ≤ 30.1 cm for men and CC ≤ 27.3 cm for women, group 2 CC > 30.1 cm and CC > 27.3cm (women)

Table 3. Sensitivity and specificity of CC cut-off points in predicting nutritional risk as assessed using anthropometric, biological and clinical assessments in Cohort 2

Parameter	*Sensitivity (%)*	*Specificity (%)*	*PPV (%)*	*NPV (%)*
BMI<18.5kg/m2 vs BMI ≥ 18.5 kg/m2)	81.3	85.9	55.3	95.5
SGA C vs SGA A & B	84.6	83.9	46.8	97.0
Low MUAC (<23.0 cm-men, <22.0 cm- women) vs normal	75.9	83.6	46.8	94.8
Low albumin <33g/L vs normal	34.7	80.2	55.3	63.4

Abbreviations: PPV- positive predictive value; NPV- negative predictive value

would be an increase in the sensitivity and specificity for identifying the nutritional risk in the elderly. Furthermore, a study in Finland used 35.2cm CC cut-off point for both men and women in the MNA (Soini, Routasalo & Lagström, 2004).

As mentioned earlier, MNA is a tool that was developed based on data from the European countries, thus it is necessary to modify the tool with as much country- or region-specific data and criteria as possible for it to be a truly useful screening tool for the non-Caucasian populations (Guigoz *et al*., 1997). Some studies were done in the Asian countries, for example, Taiwan, India, Indonesia, and Japan (Table 4). A study among the Taiwanese elderly population found that low CC and low MUAC were more effective than low BMI in determining malnutrition for people aged between 65 to 74 years old (Tsai & Chang, 2011. The authors also reported that low CC together with low BMI was more effective than low MUAC for people aged more than 75 years old in detecting malnutrition. Meanwhile, for people aged 53 to 64 years old, low BMI was more effective in determining malnutrition than using the low MUAC and CC values. Thus, low CC measurement is more effective in determining malnutrition

Table 4. Calf circumference cut-off points for elderly in some countries

	Country	*Sample size*	*Settings*	*Age (Years)*	*Calf circumference cut -off point (Cm)*		*References*
					Men	*Women*	
World Country	France	n= 622 frail elderly	Clinical centers and healthy elderly from university in Toulouse, France	≥65	<31.0	<31.0	Guigoz *et al.*, 1997
	France	n= 1458 elderly French women	Community setting in France	≥70	-	<31.0	Rolland *et al.*, 2003
	France	n= 911 elderly patients	Hospitalized elderly	≥80	<30.5	<30.5	Bonnefoy *et al.*, 2002
	Brazil	n= 132 elderly patients	Hospitalised elderly	≥60	<32.2	<32.2	Aparecida *et al.*, 2012
	Finland	n = 178 elderly	Home care services	75 - 94	<35.2	<35.2	Soini *et al.*, 2004
Asian Country	Taiwan	n= 4191 elderly	Regular households, homes for the elderly, nursing homes, long term care hospitals	≥53	<30	<27	Tsai & Chang, 2011
	Taiwan	n= 2890 elderly	Regular households, homes for the elderly, nursing homes, long term care hospitals	≥65	<28	<25	Tsai *et al.*, 2007
	India	n= 500 elderly	Free living and institutionalised elderly	≥60	<31	<31	Jose & Kumar, 2014
	Indonesia	n= 702 elderly patients	Elderly in outpatient clinics of hospitals	≥60	<34.8	<32.5	Setiati *et al.*, 2010
	Japan	n= 90 elderly	Nursing homes	≥65	≤23.6	≤23.6	Tajima *et al.*, 2003

and also predicting mortality risk for people aged more than 65 years old. Further studies found that the application of these modified cut-points improved the usefulness of the MNA in the Taiwanese elderlies under various life settings (Tsai & Ku, 2008; Tsai & Shih, 2009; Tsai *et al*., 2009).

Based on a research article from South India, MNA was found to be applicable in identifying malnutrition in the elderly (Jose & Kumari, 2014). In the study, four main aspects were involved; the clinical assessment, anthropometry, biochemical indices and also MNA assessment. As for the anthropometry part, CC has been considered to provide the most sensitive measure of muscle mass especially in the elderly. In addition, it was found that when CC was compared to MNA in identifying true malnourished and well-nourished elderly, MNA appeared to show fair sensitivity (power to identify true malnourished) at 73.4% accuracy but has an excellent specificity (power to identify true well nourished) at 98.21% accuracy. Thus, it can be said that MNA can be used to identify malnourished and well-nourished elderly with reasonable accuracy.

Malnutrition Universal Screening Tool (MUST) is another non-invasive nutritional risk screening tool developed by the Multidisciplinary Malnutrition Advisory Group of the British Association for Parenteral & Enteral Nutrition (BAPEN) of the United Kingdom for adults under all healthcare settings and patient groups (Vellas *et al*., 2006). This tool was also developed on the basis of clinical data of the Western populations. Its use beyond the Western populations has not been documented. Like the MNA, it should also be modified when applied to the non-Western populations. A recent study concluded that the adoption of the population-specific anthropometric cut-off points improved the grading ability of both the MNA-Short Form (MNA-SF) and MUST over the original scales (Tsai *et al*., 2009). This is an important step in maintaining the true content equivalency of imported measurement tools. The study also highlighted that CC can replace BMI in both the MNA-SF and MUST scales without compromising the grading ability.

In Cohort 2, there was a significant correlation of the CC values to other nutritional status indicators such as BMI, MUAC, and serum albumin for CC for both men and women with CC less than 30.1cm and 27.3cm, respectively. The cut-off points of CC determined in Cohort 1 were used in Cohort 2. This showed that CC is a reliable anthropometric parameter in determining the risk of malnutrition among the elderly.

The prevalence of mild to moderate malnutrition determined by using SGA in Cohort 1 was 53.9% and 33.1% for men and women, respectively. On the other hand, the prevalence of mild to moderate malnutrition in Cohort 2 was 68.7% and 73.5% for hospitalised men and women respectively by using SGA. There was a higher prevalence of malnutrition among hospitalised elderly compared to those who were not hospitalised. This issue should be addressed as malnourished hospitalised elderly is often associated with poor outcomes such as longer hospital stay, higher occurrence of complications, and higher in-hospitalisation costs (Wu *et al*., 2009).

Strength and limitations

A major strength of this study is that it represents the three major ethnic groups of Malay, Chinese, and Indians in Malaysia. However, this study has limitations. Firstly, a small sample size was used in this study, specifically in Cohort 2. Besides, the measurement of the calf-circumference depends on the technique and skills employed by the examiner. There is a possible occurrence of random error during calf circumference measurements.

CONCLUSION

In conclusion, the measurement of calf circumference is a non-invasive and economical approach that can facilitate the evaluation of the nutritional status of elderly individuals. A value of < 30.1cm (man) and < 27.3cm (woman) will classify a subject as malnourished. These cut-off points can be used by health professionals in Malaysia to screen the elderly individuals who are at risk of malnutrition. The predictive value of the CC cut-off point was 32.0 ± 4.2 cm in men and 30.5 ± 4.6 cm in women. It is recommended that the healthcare professionals be trained to develop the skills of taking CC measurement in order to identify the risk of malnutrition among the elderly, especially those who are hospitalised, as early as possible, so that proper nutrition support can be provided and overall outcomes can be improved.

Conflict of interest

The authors have no conflict of interest. All authors participated in the drafting of this manuscript and have read and approved the final version.

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