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The cut-off values of anthropometric variables for predicting mild cognitive impairment in Malaysian older adults: a large population based cross-sectional study

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Purpose: Older adults are at risk of mild cognitive impairment (MCI), and simple anthropometric measurements can be used to screen for this condition. Thus, the aim of this study was to explore the cut-off values of body mass index (BMI) and waist circumference (WC) for predicting the risk of MCI in older Malaysian adults.

Methods: A total of 2,240 Malaysian older adults aged ≥60 years were recruited using multistage random sampling in a population based cross-sectional study. Receiver operating characteristic (ROC) curve was used to determine the cut-off values of BMI and WC with optimum sensitivity and specificity for the detection of MCI. Age, gender, years of education, smoking habit, alcohol consumption, depression, and medical conditions were used as confounding factors in this analysis.

Results: A BMI cut-off value of 26 kg/m^2 (area under the receiver operating characteristic curve [AUC] 0.725; sensitivity 90.5%; specificity 38.8%) was appropriate in identifying the risk of getting MCI in both men and women. The optimum WC cut-offs for likelihood of MCI were 90 cm (AUC 0.745; sensitivity 78.0%; specificity 59.8%) for men and 82 cm (AUC 0.714; sensitivity 84.3%; specificity 49.7%) for women. The optimum calf circumference (CC) cut-off values for identifying MCI were 29 cm (AUC 0.731; sensitivity 72.6%; specificity 61.1%) for men and 26 cm (AUC 0.598; sensitivity 79.1%; specificity 45.3%) for women.

Conclusion: The cut-off values could be advocated and used as part of the screening of MCI among older Malaysian adults. There is a need to further determine the predictive values of these cut-off points on outcomes through longitudinal study design.

Keywords: body mass index, BMI, cut-off values, MCI, older adults, waist circumference, WC

Introduction

Mild cognitive impairment (MCI), usually a transition state between age-related cognitive changes and dementia (also known as major neurocognitive disorder), is one of the most relevant issues in the field of aging studies.[1] MCI is clinically diagnosed with the presence of memory complaints, preferably confirmed with the use of neurocognitive tools, intact activities of daily living, and no history of dementia.[2] Older adults aged 60 and above with MCI are at risk of having dementia, as more than 50% will progress to have dementia within 5 years of being diagnosed with MCI, while some of the older adults remain stable or return to normal over time.[3] Much effort has been devoted to preventing the development and progression of this disease, as the aging population is increasing.[4–6]

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An important predictor of cognitive decline is the amount of body fat and muscle mass. A few studies have reported that body fat and muscle mass play a role in the development of cognitive impairment.[7–10] Body fat has been associated with presence, or severity, of white matter lesions and loss of gray matter volume in the brain, which affect cognitive function.[11,12] Loss of muscle mass subsequently affects physical performance and cognitive impairment.[13]

Body mass index (BMI), waist circumference (WC), and calf circumference (CC) are simple, reliable, and inexpensive tools to assess the amount and distribution of body fat and muscle mass. The World Health Organization (WHO) has suggested cut-off values for BMI of 30 kg/m^2 and 25 kg/m^2 for identifying obesity in Western countries and Asia, respectively.[14,15] The International Diabetes Federation has also proposed a WC of 90 cm for men and 80 cm for women for determination of abdominal obesity.[16] Anthropometric cut-off values have been used to determine nutritional status and predict health outcomes related to obesity including chronic diseases.[13,17] However, their predictive values on cognitive impairment are yet to be determined.

Body composition has been used as a marker for obesity and sarcopenia.[18,19] With the increasing older population, the availability of simple tools for measuring body fat and muscle mass, and the evolving interest of scientific and health care communities in determining the impact of body composition on cognitive function, there are needs to explore further for identifying the risk of MCI. Therefore, the present study aimed to estimate the cut-off values of BMI, WC, and CC to identify MCI among multi-ethnic Malaysian older adults recruited through multistage random sampling of a large community-based population study.

Methods

Ethics statement

This study was part of the Long-term Research Grant Scheme Towards Useful Aging (LRGS TUA-NN-060-2013) project and was approved by the Secretariat for Research and Ethics of Universiti Kebangsaan Malaysia. All respondents provided signed written informed consent prior to their participation in this study.

Subjects and design

This study was conducted within the framework of the LRGS-TUA study among Malaysian elderly aged ≥60 years old.[20] The sampling for this study was done with the assistance of the Department of Statistics, Malaysia. Peninsular Malaysia was divided into four regions, and the sampling method involved three stages. The first stage sampling involved selection of one state from each region. The second stage sampling was the random selection of 35 census circles from each selected state, and within each selected census circle 20 living quarters (LQ) were randomly selected (third stage sampling). All eligible individuals in the selected LQ were included in the survey. In this study, a total of 2,322 older adults were selected. Older adults who had: 1) severe vision, hearing, and speech problems; 2) terminal illness; 3) previously diagnosed psychiatric conditions, including depressive disorders and dementia; 4) serious disability; and 5) dependence on drugs or alcohol were excluded. Respondents were invited to gather at community centers for data collection. Sociodemographic, functional status, and neuropsychological status were assessed through face-to-face interview, and anthropometric measurements were elicited by trained field workers.

Potential confounding variables

A few sociodemographic factors including age, education, smoking, alcohol consumption, and medical history (such as hypertension, diabetes mellitus, and hypercholesterolemia) which might influence MCI and anthropometric measurements were obtained using self-reported questionnaires. Another possible confounding factor was the presence of coexisting undiagnosed depression which was detected using the 15-item Geriatric Depression Scale (GDS-15).[21]

Assessment of MCI

General cognitive functioning was measured using the Malay version Mini-Mental State Examination (M-MMSE). This version is more culturally acceptable to the study population as compared to the original English version.[22] Objective cognitive impairment was measured using Rey Auditory Verbal Learning Test (RAVLT).[23] Functional status was assessed based on 13 questions measuring disabilities in activities of daily living (ADL) and instrumental activities of daily living (IADL).[24,25] Self-reported memory complaint was assessed with the following question: "Do you feel you have more problems with memory than most?". In this study, older adults were defined as having MCI when all the following criteria were present: MMSE ≥19; RAVLT T5 ≥34; ADL =6; IADL ≥9; and the presence of self-reported memory complaint.[1]

Assessment of anthropometric measurements

Anthropometric measurements were taken using a standard protocol.[26] Height was taken to the nearest 0.1 cm using

Table 1 Baseline characteristics of participants categorized by MCI

Characteristic	Total	MCI (n=331)	Non-MCI (n=1,909)	*P*-value
Age, years	69.1±6.2	69.5±5.9	68.4±5.9	0.002*
Men, %	48.0	55.7	48.8	0.011**
Education, years	5.1±4.0	4.5±3.2	5.6±4.0	<0.001*
Currently smoking, %	17.1	21.6	16.2	0.027**
Alcohol consumption, %	4.2	3.6	4.3	0.542
Hypertension, %	50.6	53.9	50.0	0.085
Hypercholesterolemia, %	31.3	34.1	30.7	0.319
Diabetes mellitus, %	27.0	29.0	26.6	0.779
GDS-15, score	2.7±2.3	3.8±2.5	2.4±2.1	<0.001*
BMI (kg/m^2)	25.0±4.4	25.2±4.4	25.1±4.4	0.039*
WC (cm)	88.2±11.3	88.7±11.0	88.2±11.3	0.045*
CC (cm)	33.3±3.8	33.2±3.89	33.6±3.4	0.032*

Notes: Data are presented as mean ± SD. *Using independent *t*-test (2-tailed) with 95% CI. **Using chi-square test (2-sided).
Abbreviations: MCI, mild cognitive impairment; GDS-15, 15-item Geriatric Depression Scale; BMI, body mass index; WC, waist circumference; CC, calf circumference; CI, confidence interval; SD, standard deviation.

Leicester Height Measure. Weight was determined to the nearest 0.1 kg using calibrated weighing scale Tanita HD 319 (Tanita Corporation of America, Arlington Heights, IL, USA). Further, BMI was calculated as weight in kilograms divided by height in meters squared. WC was measured at a level midway between the lower rib margin and iliac crest with a Lufkin tape all around the body in horizontal position, to the nearest 0.1 cm. CC was measured at the most prominent part of the right calf using Lufkin tape in a sitting position, to the nearest 0.1 cm.

Statistical analyses

All statistical analyses were performed using SPSS software (version 22.0; IBM Corp., Armonk, NY, USA). Statistical significance was assessed at the level of 0.05 (2-tailed) and $P<0.05$. Pearson X^2 and Student's *t*-test were used to determine if there was a significant difference between MCI and non-MCI groups. Receiver operating characteristic (ROC) analysis was performed to determine the optimal cut-off values of BMI, WC, and CC with optimum sensitivity and specificity for identification of MCI. Sensitivity is defined as the probability of correctly identifying those with MCI for given BMI cut-off values, WC cut-off values, or CC cut-off values. Specificity is defined as the probability of correctly identifying those without MCI at given BMI cut-off values, WC cut-off values, or CC cut-off values. The optimal cut-off values were defined as the point at which Youden Index (sensitivity + specificity −1) was highest. The area under the ROC curve (AUC) with 95% confidence intervals was generated to indicate the diagnostic performance of BMI, WC, and CC for detecting those with MCI. A test is considered perfect if AUC is 1.0 and is considered no better than chance if AUC is 0.5.

Results

Out of a total of 2,322 Malaysian older adults invited to participate, 2,240 older adults completed all the tests (response rate 96.5%). The respondents consisted of 48.0% men, 49.4% urban dwellers. The majority were Malays (63.4%), followed by Chinese (32.1%), Indians and others (4.5%). The mean age of subjects was 69.1±6.2 years as shown in Table 1. A total of 331 (14.7%) respondents were classified as MCI, particularly among men and those who reported that they had lower education ($P<0.05$ for both parameters). Respondents with MCI, had a significantly higher mean BMI, WC, and GDS-15 scale, and lower mean CC than those without MCI ($P<0.05$ for all parameters).

The predictive values for MCI and corresponding AUC of BMI and WC are shown in Tables 2 and 3, respectively.

Table 2 AUC, sensitivities and specificities of optimal BMI cut-offs associated with MCI for Malaysian older adults

BMI cut-off (kg/m^2)	AUC (95% CI)	Sensitivity (%)	Specificity (%)	Youden index
23	0.725 (0.693, 0.758)	88.1	39.3	27.4
24	0.724 (0.692, 0.757)	88.5	39.0	27.5
25	0.725 (0.692, 0.757)	90.1	38.8	28.9
26	0.725 (0.692, 0.757)	90.5	38.8	29.3
27	0.724 (0.692, 0.757)	89.3	38.9	28.2
28	0.725 (0.693, 0.757)	89.7	38.2	27.9

Notes: Adjusted for age, gender, years of education, smoking habit, alcohol consumption, hypertension, hypercholesterolemia, diabetes mellitus, and depression.
Abbreviations: CI, confidence interval; AUC, area under the ROC curve; ROC, receiver operating characteristic; MCI, mild cognitive impairment; BMI, body mass index.

Table 3 AUC, sensitivities and specificities of optimal WC cut-offs associated with MCI by gender for Malaysian older adults

WC cut-off (cm)	AUC (95% CI)	Sensitivity (%)	Specificity (%)	Youden index
Men				
88	0.745 (0.705, 0.786)	76.7	58.5	35.2
89	0.745 (0.705, 0.786)	76.7	58.7	35.4
90	0.745 (0.704, 0.785)	78.0	59.8	37.8
91	0.745 (0.705, 0.786)	78.0	59.7	37.7
92	0.745 (0.705, 0.786)	76.7	60.0	36.7
93	0.745 (0.704, 0.785)	77.3	59.7	37.0
Women				
78	0.714 (0.666, 0.763)	83.3	49.7	33.0
79	0.715 (0.665, 0.765)	82.4	50.7	33.1
80	0.715 (0.666, 0.764)	83.3	49.9	33.2
81	0.715 (0.666, 0.764)	83.3	49.7	33.0
82	0.714 (0.666, 0.763)	84.3	49.7	34.0
83	0.715 (0.666, 0.764)	83.3	50.7	34.0

Notes: Adjusted for age, gender, years of education, smoking habit, alcohol consumption, hypertension, hypercholesterolemia, diabetes mellitus, and depression.
Abbreviations: CI, confidence interval; AUC, area under the ROC curve; ROC, receiver operating characteristic; MCI, mild cognitive impairment; WC, waist circumference.

BMI at a cut-off value of 26 kg/m^2 resulted in the highest Youden Index with the corresponding sensitivity of 90.5% and specificity of 38.8% in identification of individuals at risk of MCI. At the WHO cut-off values of BMI $\geq$25 kg/m^2 for overweight,[15] the Youden Index dropped by 0.5. BMI with AUC of 0.725 was a good indicator for MCI. The optimum WC cut-off values with the highest Youden Index for identifying MCI were 90 cm for men and 82 cm for women. The AUC of WC in men (0.745) was higher than in women (0.714) ($P<0.05$). The predicting values for MCI and corresponding AUC of CC are reported in Table 4. The optimum CC cut-off values with the highest Youden Index for identifying MCI were 29 cm for men and 26 cm for women.

Prevalence of MCI in older adults with BMI cut-off 26 kg/m^2, is shown in Figure 1. With optimal BMI cut-off values in the present study, 38% of the study population were identified as having MCI. When compared to the cut-off values as suggested by WHO for overweight, older adults having MCI decreased by 8%. Figure 2 shows prevalence of older adults at risk of MCI using waist circumference cut-off according to gender. It was found that by using optimal WC cut-off values, 55% of men and 33% of women in this population were identified having MCI.

Table 4 AUC, sensitivities and specificities of optimal CC cut-offs associated with MCI by gender for Malaysian older adults

CC cut-off (cm)	AUC (95% CI)	Sensitivity (%)	Specificity (%)	Youden index
Men				
24	0.724 (0.687, 0.761)	72.0	60.0	0.320
25	0.724 (0.687, 0.761)	71.5	60.0	0.315
26	0.726 (0.690, 0.763)	71.0	60.1	0.311
27	0.725 (0.688, 0.762)	69.9	60.7	0.306
28	0.724 (0.687, 0.761)	72.6	60.5	0.331
29	0.731 (0.694, 0.768)	72.6	61.1	0.337
30	0.726 (0.688, 0.763)	71.5	61.7	0.332
31	0.724 (0.687, 0.761)	71.5	60.4	0.319
32	0.724 (0.687, 0.761)	70.4	60.2	0.306
Women				
24	0.606 (0.546, 0.666)	78.4	45.7	0.241
25	0.610 (0.550, 0.669)	78.4	45.1	0.235
26	0.598 (0.537, 0.659)	79.1	45.3	0.244
27	0.611 (0.550, 0.671)	78.4	45.4	0.238
28	0.611 (0.551, 0.670)	76.4	45.8	0.222
29	0.611 (0.552, 0.671)	76.4	45.7	0.221
30	0.612 (0.553, 0.672)	75.0	46.9	0.219
31	0.612 (0.554, 0.673)	77.1	46.1	0.232
32	0.610 (0.550, 0.669)	77.0	45.9	0.229

Notes: Adjusted for age, gender, years of education, smoking habit, alcohol consumption, hypertension, hypercholesterolemia, diabetes mellitus, and depression.
Abbreviations: AUC, area under the ROC curve; ROC, receiver operating characteristic; MCI, mild cognitive impairment; CI, confidence interval; CC, calf circumference.

Discussion

This is the first study on MCI exploring the predictive values of simple anthropometric measurements in relation to MCI. Respondents in this study were recruited through a multistage random sampling and had similar characteristics to the Malaysian elderly from the National Census data,[27] thus were considered as representative of a multi-ethnic older adult population in Malaysia. The low education level

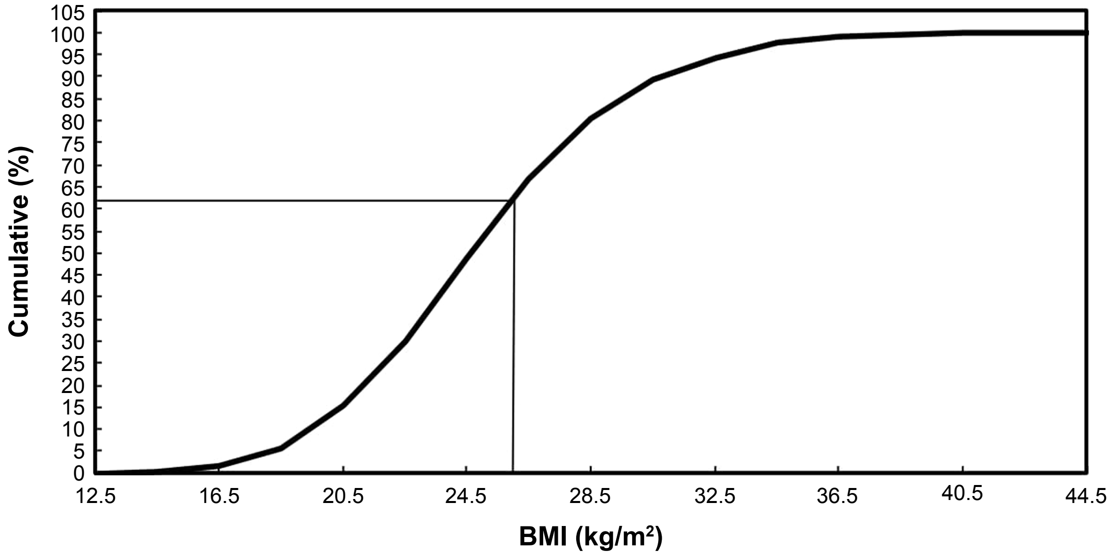

Figure 1 Prevalence of older adults at risk of MCI using BMI cut-off 26 kg/m^2.
Abbreviations: MCI, mild cognitive impairment; BMI, body mass index.

of the respondents was in agreement with that reported in an earlier study, the Mental Health and Quality of Life of Older Malaysian, which noted that 90.2% had only primary education. Low education level is an indicator of socioeconomic disadvantage that may begin in early life and is associated with impaired cognitive function.[28] Besides this, most respondents in this study were not working or had retired as reported in the previous study with the same population.[20]

As reported in other studies,[29–32] MCI subjects in this study had a higher prevalence of chronic diseases including diabetes mellitus, hyperlipidemia, and hypertension and were at risk of obesity and also depression. Thus, all these factors were considered as covariates in the ROC curve analysis. Older adults have a tendency to develop progressively increasing fat depots especially in the truncal and abdominal areas.[33] Increased intra-abdominal fat accumulation has been known to be related to insulin resistance associated with chronic diseases which may impair brain function and cognitive processes.[34,35] Waist circumference was also found to be closely related to the total body fat measured by computerized tomography.[36] Prevalence of smoking was reported significantly higher in the MCI group compared to the

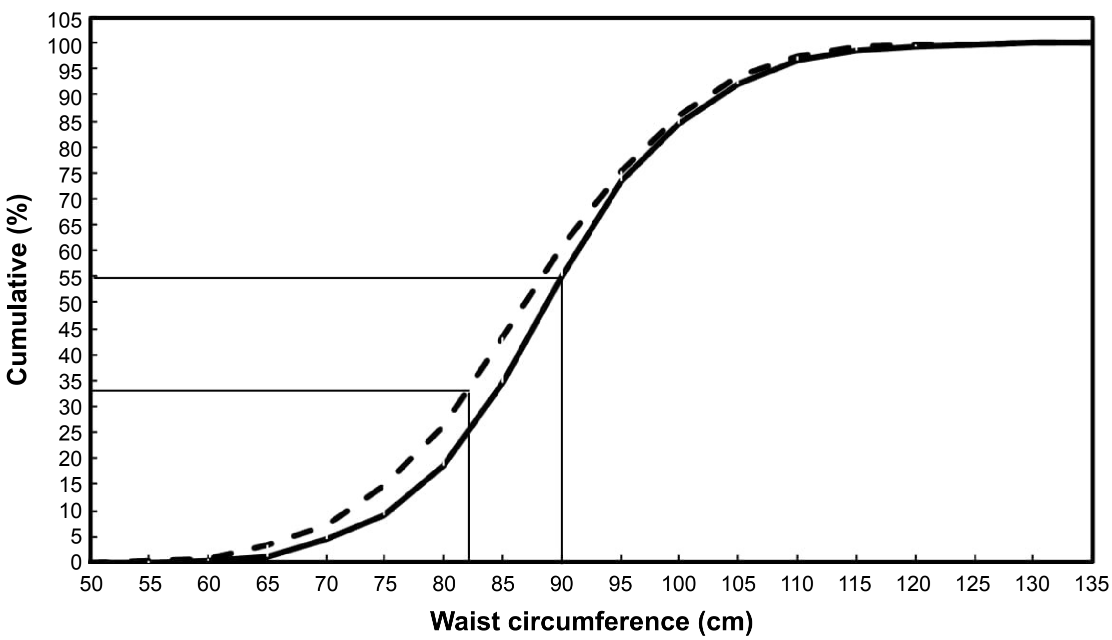

Figure 2 Waist circumference percentile distribution curves of Malaysian older adults men (–) and women (- - -).
Notes: Prevalence of older adults at risk of MCI using waist circumference cut-off 90 cm for men (–) and 82 cm for women (- - -).

non-MCI group. The association between smoking and MCI is consistent with results from other studies.[37,38] Smoking was found to correlate with vascular disease, and increased oxidative stress which was related to cognitive impairment.[39,40]

This study demonstrated that a BMI of 26 kg/m^2, and WC of 90 cm in men and 82 cm in women, were optimal cut-off values in identifying those with MCI, after controlling for age, education, medical history, smoking habit, alcohol consumption, and depression. The diagnostic performance of BMI and WC cut-off values is assessed by calculating their sensitivity and specificity for identifying MCI. This present study showed that the optimal BMI cut-off values correctly determined $>$90% of those with MCI and correctly identified $>$35% of those without MCI. Whilst for WC, the optimal cut-off values correctly identified $>$70% of those with MCI and $>$50% for those without MCI. Using a high sensitivity is vital in clinical and public health practice. Higher sensitivity ensures that the screening tools do not miss out older adults who have cognitive impairment, subsequently suitable treatment can be given to those who truly have the risk. Having optimal cut-off values could help create awareness about the potential risk of MCI among those in the overweight category.

The cut-off value for BMI of 26 kg/m^2 developed in this study, is almost comparable to the values used to assess overweight for adults of more than 24.9 kg/m^2, as suggested by WHO.[15] It should be kept in mind that consensus on an optimal BMI for older adults is still lacking. However, there are suggestions that older adults be allowed to have a higher level of BMI at 27 kg/m^2, as lower values are associated with a higher risk of morbidity and mortality, as evidenced from a few longitudinal studies.[41–43] Nevertheless, older adults with a high risk of chronic diseases are advised to monitor their body weight regularly. Thus, the BMI cut-off of 26 kg/m^2 suggested in this study seems reasonable to be applied in a multi-ethnic population with high risk of chronic diseases, particularly in Malaysia. Recent data from the National Health and Morbidity Survey (NHMS) 2015 indicated the prevalence of diabetes mellitus (17.5%), hypertension (30.3%), and hypercholesterolemia (47.7%) among Malaysians aged $\geq$18 years were on the rise as compared to the NHMS 2011.[44,45]

Similarly, the cut-off values of WC 90 cm and 82 cm for men and women, respectively, in this study were not very much different from those recommended by the International Diabetes Federation (IDF) for adults.[46] The cut-off values suggested in this study are indicating MCI among those with abdominal obesity. Waist circumference is a simple measurement to assess obesity, where measurement can be performed by wrapping a flexible measuring tape in between the lowest rib and the top of the hip bone. However, for older adults, especially among those with weight problems and the obese, accurate waist circumference is difficult to obtain. Therefore, in this study, waist circumference of obese older adults was measured at a vertical level, 1 inch above the umbilicus.[47]

CC has been recommended by the European Working Group on Sarcopenia in Older People (EWGSOP) to be used in routine clinical practice to assess muscle mass as CC correlates positively with muscle mass.[48] The current study CC cut-off value of 26–29 cm is lower than the value used to identify disability for older adults of less than 31 cm.[49] However, Tsai et al[50] have suggested the cut-off value of CC 28 cm while Harith et al[51] have suggested the CC cut-off value of 27–30 cm to be used in identifying malnourished state, which is similar to our findings. As CC increases, physical performance and muscle strength improves significantly. Studies have reported that better physical performance and muscle strength are associated with better cognitive function.[13]

Despite being the first population-based cohort study to report the cut-off values for identifying MCI from simple anthropometric measurements, this study has its own limitations. This study did not provide comparative data between the younger and older participants to assess different BMI and WC criteria according to the changes in body composition. Besides this, the respondents of this study did not include older adults from East Malaysia due to budget and logistical reasons. This study also has its strength in using actual measurements of anthropometric variables rather than merely self-reported data. Several MCI risk factors were examined during data analyses.

Conclusion

The findings indicated that BMI and WC were higher, but CC was lower, in participants with MCI. Results also suggested that Malaysian older adults with BMI $\geq$26 kg/m^2, WC $>$90 cm (men) and $>$82 cm (women), and above, or CC $<$29 cm (men) and $<$26 cm (women) had increased likelihood of having MCI. These cut-off values should be advocated and used by health professionals in the screening of MCI among community-dwelling older adults.

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Disclosure

The authors report no conflicts of interest in this work.

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