

Does obesity affect cognitive functions in middle-aged adulthood? A comparative study in Sri Lanka

Pushpika Ariyasinghe

General Sir John Kotelawala Defence University

Ruwan Kumara

General Sir John Kotelawala Defence University

Daham Alexander

General Sir John Kotelawala Defence University

Harsha Senarathna

General Sir John Kotelawala Defence University

Sunethra Kasthuri

General Sir John Kotelawala Defence University

Lahiru Sandaruwan Galgamuwa (✉ lahiruahs@yahoo.com)

Faculty of Health Sciences, The Open University of Sri Lanka

Nimantha Karunathilaka

General Sir John Kotelawala Defence University

Sudath Warnakulasuriya

University of Colombo

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Abstract

Background Cognition is the collection of an intellectual process, such as perception, thinking, reasoning and remembering for goal-directed behaviors. Recent studies have shown that obesity associated with poor cognitive functions (CFs). However, this association is not known in the Sri Lankan context. The objective was to determine the association of cognitive function and obesity among middle-aged adults in Colombo district, Sri Lanka

Methods A comparative cross-sectional study was conducted among 166 middle-aged adults aged 50-60 years in a selected MOH division in Colombo District, Sri Lanka. Generalized and central obesity were determined using the WHO cutoff of Body Mass Index (BMI) and Waist Hip Ratio (WHR) values. CFs were assessed using validated Montreal Cognitive Assessment (MoCA) and Mini Mental State Examination (MMSE) tools.

Results The study sample consisted 83 subjects of each obese and normal weight categories while 50% were females. Obese middle-aged adults showed significantly lower CF scores in both MoCA and MMSE compared to the normal-weight adults. In addition, lower MMSE scores were significantly associated with high WHR values. Education level of the obese people was a significant predictor of the cognitive functions.

Conclusion Obese middle-aged adults had poor cognition compared with their normal-weight subjects. Therefore, remedial actions need to be taken to overcome adulthood obesity for better neuropsychological functions in the brain.

Background

Obesity is a multifactorial health problem affecting both developed and developing countries worldwide [1]. In the year 2014, there had been around two billion overweight and more than half a million obese individuals in the world [2]. According to the Sustainable Development Goal (SDG), the prevalence of Sri Lankan obese adults was 6.2% in 2017 and this number was comparatively higher than the regional countries [3]. However, obese adult population has been increasing over recent decades. Higher socioeconomic status and the ethnicity of Moors have been identified as factors that more vulnerable to obesity. Besides, obesity leads to many public health problems and increases the economic burden of health care [4].

Cognition represents the behaviour characteristics of the individuals as a whole and consistent with different abilities which are specific to the individuals. However, other factors such as lifestyle and motor skills may influence cognition [5]. The prefrontal cortex (PFC) which is involved in the control of cognition and its associated behaviour, has the longest maturation period in the brain [6].

Obesity and excessive fat intake lead to systemic inflammation and free fatty acids level in the body. Circulating cytokine, extra fatty acids and immune cells get through the brain at the level of

hypothalamus for exacerbating the local inflammation which leads poor cognitive functions (CFs) [7]. Moreover, CF is predominantly lower amongst obese adults irrespective of their medical comorbid conditions [8, 9]. Further, studies reported that adults with higher BMI had shown a lower level of cognition [8, 10]. Obese individuals had experienced poorer memory performance in learning, lower physical performances, delayed recall and recognition when compared to normal middle-aged adults [11, 12]. Verbal memory and decision making are the core components of cognition and these aspects were significantly lower in obese adults when compared to its normal weight subjects [13]. In addition, performances in psychomotor and speed tests too were significantly lower in obese subjects in several studies [8, 14]. Furthermore, Gunstad and colleagues revealed that poor cognitive function scores had been reported among obese subjects across the life span [10, 11]. However, the paucity of published data available in the South Asian region with the obesity and CFs, this study was designed to determine the association between obesity and CFs among middle-aged adults in Colombo District, Sri Lanka.

Method

Study population and sample size

The functional health care system of Sri Lanka has been decentralized to MOH areas with the purpose of better administration and health care provision. Since the study was conducted as a comparative study, the numbers of obese adults recruited were the same as normal-weight adults. Classification of BMI groups was based on the WHO Asian cut-off values for assessing generalized obesity [15]. Normal weight was considered as BMI range between 18.5 to 22.9 Kg/m² while obese was considered as BMI above 27.5 Kg/m² [15]. Central obesity was measured by recruited study sample (normal-weight vs. obese), using the WHO cutoff values (normal WHR for males was <0.90 and normal WHR for females was <0.80) respectively [16]. Height was taken to the nearest 0.1 cm, as the maximum distance to the uppermost position on the head from heels, with the individual standing barefoot and in full inspiration using SECA stadiometer (SECA model 240). Body weight was measured to the nearest 0.1 kg using a SECA digital weighing scale with the participants wearing indoor light clothing. Weighing scales were calibrated at each 25th measurement. BMI was calculated as weight in kilograms divided by height squared in meters (kg m²).

The sample size was calculated using the equation of $n = z^2 p (1-p) / d^2$. Minimal sample size was calculated as 83. Meantime, similar subjects of normal weight adults (n=83) were recruited from the population to the comparison group. Therefore, a total of 166 adults were recruited by using electorate register as a sampling frame.

Data Collection

Montreal Cognitive Assessment Test (MoCA)

MoCA has been developed to determine individuals with impaired cognitive functions that generally run in the normal range of the MMSE. It covers eight cognitive domains: visuospatial skills, executive functions, recovery of short-term memory and attention, concentration, working memory, language and orientation. It gives a maximum of 30 scores and individuals' score over 26 is considered normal and less than 26 is detected as Mild cognitive impairment (MCI). The MoCA has been culturally adapted and validated to Sri Lankan context in 2011 [17].

Mini Mental Status Examination (MMSE)

The MMSE is the best known and most widely used measure of cognition in clinical practice worldwide. MMSE assesses cognitive function from the domains of orientation, memory, attention and calculation, language and visual construction. The score range between 0 and 30 points and cutoffs of 23/24 have typically been used to show significant cognitive impairment [18]. However, studies conducted in symptomatic populations with similar educational and socioeconomic backgrounds that the cutoff values of MMSE can be waived off up to 26/27 [19, 20].

According to the Dementia and Driving Safety, A Clinical guideline for the categorization of the level of cognition was developed and tabulated below for both MoCA and MMSE (Table 1) [21].

Table 1: Dementia staging and the clinical Dementia rating scale:

Cognition Level	MMSE	MoCA
Normal	27-30	26-30
MCI	24-26	18-25
Mild Dementia	18-23	11-17
Moderate Dementia	10-17	6-10
Severe Dementia	Below 10	Below 6

Data Analysis

Data were analyzed using SPSS version 20. Descriptive statistics were reported as mean and Standard Deviation (SD) for continuous variables and frequencies and percentages for categorical variables. The data were analyzed using independent samples 't' test for obtaining differences of means scores since the distribution was normal. The significant association between categorical variables were analyzed by the chi-square test. Multiple Linear Regression (MLR) model was performed to determine the factors associated with CFs among middle-age adults without gross violations of basic assumptions.

Furthermore, variables that are highly correlated and measuring the same construct were not considered when performing MLR [22]. The level of significance was set at p value less than 0.05.

Results

General Characteristics of the study sample

There was a significant association in the distribution of gender and monthly income between normal-weight and obese categories ($p < 0.05$) while, no significant association was found in the level of education between normal-weight and obese categories (Table 2). A significantly higher mean BMI and WHR values were observed in the obese group when compared normal weight group (Table 3).

Table 2. Socio-demographic characteristics of the study sample (Normal weight vs. obese)

Variable	Normal weight n=83 (%)		Obese n = 83 (%)		p value
Gender					
Male	53	(63.9)	30	(36.1)	0.001
Female	30	(36.1)	53	(63.9)	
Education Level					
≤ GCE O/L	51	(51.0)	49	(49.0)	0.751
GCE A/L >	32	(48.5)	34	(51.5)	
Monthly Income					
≤ SLR 40,000.00	52	(50.0)	52	(50.0)	0.001
SLR 40,0000.00 >	31	(50.0)	31	(50.0)	

(Chi-Square test)

Table 3. Basic anthropometric parameters of the study sample

Variable	Normal Weight (n=83)	Obese (n= 83)	p value
	Mean (SD)	Mean (SD)	
Age (Years)	54.5 (3.2)	54.7 (3.1)	0.622
Weight (Kg)	54.7 (7.3)	80.5 (8.4)	0.006
Height (cm)	159.5 (8.6)	155.8 (9.3)	0.008
BMI (Kg/m ²)	21.4 (1.6)	29.6 (2.8)	0.001
WC (cm)	83.9 (7.6)	100.7 (6.7)	0.001
HC (cm)	89.1 (5.7)	100.2 (5.3)	0.001
WHR	0.90 (0.1)	0.94 (0.1)	0.002

(Independent sample 't' test)

Performance of cognitive function tasks among normal and obese **groups**

Independent sample 't' test was performed with a group (normal and obese) as independent variables and mean scores of cognitive function domains as dependent variables. Obese subjects had significantly lower mean scores in MoCA and MMSE when compared to their normal subjects respectively (Table 4).

Table 4. Comparison of cognitive function tasks among normal and obese groups

Cognitive Function Tasks	Normal Weight	Obese	p value
	Mean (SD)	Mean (SD)	
Montreal Cognitive Assessment Test (MoCA)	131.4 (10.8)	127.3 (11.1)	0.001
Mini Mental Status Examination (MMSE)	124.6 (11.2)	122.1 (15.6)	0.002

Independent sample t test

Performance of cognitive function tasks among **normal & high WHR groups**

A significantly lower mean MMSE score was observed in high WHR group when compared normal WHR group ($p < 0.05$) while MoCA was not significant among WHR groups (Table 5).

Table 5. Compression of cognitive function tasks among WHR groups

Cognitive Function Tasks	Normal WHR (n=28)	High WHR (n=138)	p value
	Mean (SD)	Mean (SD)	
Montreal Cognitive Assessment Test (MoCA)	22.5 (4.0)	22.1 (3.0)	0.604
Mini Mental Status Examination (MMSE)	27.1 (1.8)	26.1 (2.3)	0.05

Independent sample t test

Association between BMI groups (Normal weight vs. Obese) and cognitive function tasks groups (MoCA/MMSE)

There was a significant association between CFs (cognitive impairment vs. normal cognition) and BMI groups (normal vs. obese) ($p < 0.05$) (Table 6).

Table 6. Association between BMI groups and CFs groups

Variable	Normal weight n=83 (%)	Obese n = 83 (%)	OR Normal Weight/Obese	95% CI	p value
MoCA					
Cognitive Impairment	62 (44.0)	79 (56.0)	6.70	2.20 – 20.50	0.001
Normal	19 (76.0)	06 (24.0)			
MMSE					
Cognitive Impairment	28 (39.4)	43 (60.6)	2.11	1.13 – 3.95	0.020
Normal	55 (57.9)	40 (42.1)			

(Chi-Square test)

Factors associated with cognitive function tasks

The factors that had significant associations and correlation considered as predicted variables of the model and those factors include age, gender, educational status and monthly income. Since, BMI and WHR were highly correlated and measuring the same construct of body composition, they were not considered at the same time as the predicted variable.

Multiple Linear Regression (MLR) model was performed to determine the factors associated with cognitive functions (MoCA/MMSE) among middle-aged adults. The BMI was the only determinant of MoCA and MMSE score. Around 15.0 % of the variance in the level of cognition can be explained by the observed variable while other factors that have not followed in the study, unexplained or accidental factors of the cognition (Table 7).

Table 7. Factors associated with cognitive function tasks

	Determinant	Standardized beta coefficient	p value	Adjusted R ²	F
MoCA score	Constant		0.001*	0.150	5.50
	Age	0.01	0.895		
	Gender	-0.04	0.609		
	Education status	0.15	0.841		
	Monthly income	0.16	0.718		
	BMI	-0.27	0.001*		
MMSE	Constant		0.001*	0.151	5.60
	Age	-0.05	0.482		
	Gender	-0.13	0.120		
	Education status	0.19	0.015		
	Monthly income	0.08	0.338		
	BMI	-0.22	0.004*		

Multiple Regression Model; * $p < 0.01$

Discussion

Middle-age adults in this sample was categorized into normal and obese based on WHO BMI Asian cutoff values. Therefore, 83 subjects were recruited to each group after screening their BMI values. Considering their central obesity WHR values were taken and the majority of the subjects (77%) belonged to high WHR category. Further, there was a significant positive correlation between BMI and WHR ($p < 0.001$). Similar to the present study, Mehdad et al. reported that there was a significant association among BMI, WHR, fat mass and BF% [23].

The present study revealed that a significantly lower mean composite score in MoCA and MMSE in obese subjects when compared to normal-weight subjects. Recent studies revealed that there was growing evidence between obesity and impaired performance on global cognitive function, memory, and language [8–10]. Furthermore, many studies confirmed that obesity was associated with altered neuropsychological outcomes across the life span [23–28]. Similar study conducted by Ahmadi and Kiyani found that significantly lower MMSE score among middle-aged obese adults when compared to normal-weight subjects in Tabriz, Iran [29].

The present study revealed that significantly lower MMSE values among high WHR group when compared to the normal WHR group. Similarly, high BMI, WC and WHR were associated with poorer performance on global cognitive function, memory and language [30]. Nevertheless, high WHR adults have performed decreases in block design test which was used for assessing reasoning domain when compared normal WHR middle-aged adults [31].

However, no evidence has been observed that obesity contributed to a decline in CF, even among obese individuals who displayed evidence of the metabolic syndrome and/or elevated systemic inflammation [32]. Moreover, cross-sectional study on the effect of BMI on intelligence tasks was assessed among middle-aged adults and there weren't associations between BMI and CFs tasks [33].

In the present study, blocking concept is used to control the extraneous variable which affects the consequences of the comparative study. While age, monthly income, gender were not involved in determining a associative factors for cognition, BMI and education status were predictive variables for CFs. Dore and colleagues revealed that only WHR were inversely related to the various CFs tasks with the control of age, education, gender, and the number of prior exams [34]. Recent studies have revealed that females had significantly higher cognitive impairments (MMSE) when compared to males, however, the present study revealed that gender wasn't a predominant predictor [35, 36]

Obesity contributes to the comorbidity of hypertension, diabetes, stroke, cancer etc. and also recently confirmed that higher body composition is independently correlated with poor performances on cognitive functions and dementia among middle and older adulthood [10, 37]. Recent research revealed that brain-derived neurotropic factor and leptin – biomarkers have been associated with cognitive function in human studies [38]. Thus these studies further attire the findings of the present study.

Therefore, remedial actions to be taken to overcome adulthood obesity and prevent drawbacks of the neurophysiological development in the brain during this period. Referral system should be established for counselling and follow up of those adults who were found to have poor CFs contributing to obesity. Furthermore, a longitudinal study is recommended with an intervention component and would shed further light on the contribution of obesity-related cognitive decline.

Conclusion

Results of the current study have further confirmed the association of poor cognitive function tasks in both generalized and central obese middle-aged adults when compared to their normal-weight subjects. The education status was the significant predictor of the level of cognition. Future research should seek to further clarify the causality and the cause-effect relationship between other cognitive function tasks and body compositions.

Abbreviations

CF: Cognitive Function, HC: Hip Circumference, MoCA: Montreal Cognitive Assessment, MOH: Medical Officer of Health, MLR: Multiple Linear Regression, MMSE: Mini Mental Status Examination, PFC: Prefrontal Cortex, WC: Waist Circumference, WHR: Waist to hip ratio, WHO: World Health Organization.

Declarations

Ethics approval and consent to participate

The ethical clearance was granted by the Ethical Review Committee of the Faculty of Medicine, General Sir John Kotelawala Defence University. Further, all the data collection documents and the consent form were also approved by this committee. Written Informed consent was obtained after providing information through an information sheet and verbal communication from the middle-age adults in the MOH division. Subjects were recruited after written informed consent. Privacy and confidentiality of the participants were maintained. All data obtained were securely stored and were accessible only to the investigator and supervisors.

Consent to publish

Not applicable.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Competing interests

The authors declare that they have no competing interests.

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Author Contributions

NK and PW conceived and designed the experiments. NK, PA, RW, DA, HS and SK conducted the study. Data analysis and interpretation were done by LSG and NK. The manuscript was written by NK, LSG while PW was critically revised given guidelines. All authors read and approved the final manuscript. NK, LSG and PW are guarantors of the paper.

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