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IS OBESITY ASSOCIATED WITH POOR PERFORMANCES IN WORKING MEMORY AMONGST YOUNG ADULTS? RESULTS FROM SRI LANKA."

Neurology

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ABSTRACT

Background: As recent studies have shown that obesity has been associated with poor performances in executive function (EF) tasks. Working memory (WM) is one of the core component of the EFs which is essential for the goal directed behaviours. Therefore, the study was conducted to assess the association between obesity and WM tasks in a sample of 231 young adults aged 21-25 years in Colombo District, Sri Lanka.

Method: Body mass index (BMI) and Waist to hip ratio (WHR) were calculated for estimating generalized and central obesity respectively, while Body fat percentage (BF%) was estimated through sum of three site of skin fold thickness. WM were assessed via computerized WM tasks: visuospatial (VSWM) and verbal working memory (VWM) tasks.

Results: A significant group effect was observed among BMI groups (normal, overweight and obese) and the performances in WM tasks ($F [4,454] = 10.1$, $p<0.001$). Mean scores in VSWM and VWM scores were significantly lower amongst and when compared with normal BMI subjects ($p<0.001$). Similarly, a significant lower mean scores in VSWM and VWM were observed in both male and female WHR categories when compared to their normal WHR subjects ($p<0.05$). A significant negative correlation was observed between VSWM scores and VWM scores with BF% for males and females ($p<0.05$).

Conclusions: Young adults in the study sample who were obese/overweight and had high WHR & high BF% were performed poorly in WM when compared with normal BMI and normal WHR & BF% categories.

KEYWORDS

Working memory, Obesity and Young adults

INTRODUCTION

Obesity broadly refers to excess body fat and has become an important public health problem in worldwide[1]. Nevertheless, obesity had been recognize as risk factor in various non-communicable diseases including cardiovascular diseases, diabetes, osteoarthritis, various forms of cancers, depression, obesity-related comorbidities and in cognitive impairment[2]. The increase prevalence of obesity is a major public health concern in most developed and developing countries due to rapid social transitions[3]. World Health Organization [WHO] adopted body mass index (BMI) as an accurate measurement for estimating total body fat while waist to hip ratio [WHR] for assessing pattern of distribution of fat; central obesity[4,5] which is more closely linked to some adverse health outcomes than BMI[6].

Executive functions (EFs) is a term used to describe the higher order cognitive processes which include, working memory, attention, impulsivity, mental flexibility, dis-inhibition, problem solving, and decision making[7]. One of the core process of EFs is working memory (the ability to retain relevant information temporarily as well as to use it while performing complex cognitive tasks). Pre Frontal Cortex (PFC) plays a significant role on EFs skills and it has been confirmed with various studies, including human brain lesions, brain imaging and pharmacological studies[8-10]. Furthermore, it has been found that obesity is associated with decreased cerebral blood flow in Broadmann areas of 8, 9, 10, 11, 32, and 44, in brain regions involved in attention, reasoning, and executive function by using single photon emission computed tomography [SPECT][11].

Recent studies found cognitive deficits in young adults with elevated BMI, despite having no comorbid medical conditions likely to impact cognitive function[12-14]. Further, Gunstad et al. revealed that clinically meaningful levels of impairment emerged in 23.9% of participants on tasks of memory and in 18.3% on measures of EF in obese individuals in 2010 (15). Moreover, obese children and adolescents perform worse in tests of global cognitive functioning, academic achievement and deficits in memory and learning[16-19].

The development of EF skills continues through late adolescence into early adulthood, coinciding with the growth and development of PFC[20,21]. The presence of obesity and its related medical co-morbidities in childhood/adolescence could potentially affect typical developmental acquisition of EF skills[22]. Mean prevalence percentage of Sri Lankan overweight and obese young adults (20-29 years) was 20.2% and 4.8% respectively[23]. Therefore, late adolescence and young adulthood would be the best time to assess obesity related working memory dysfunctions. There is a paucity of data on obesity related working memory in a Sri Lankan setting. Therefore, the aim of the study was to assess the association between the performances in working memory among normal, overweight and obese young adults in selected Medical Officer of Health (MOH) divisions in Colombo district, Sri Lanka.

METHODS

A descriptive cross sectional community based study was conducted on 231 young adults (77 each of normal, overweight and obese), aged between 21 - 25 years, living in three periurban MOH divisions in the district of Colombo, Sri Lanka. The subjects were randomly selected using the electoral register of each Grama Niladari (GN) division by simple random sampling (using random number table). Each participant's BMI was assessed and allocated to the BMI category. Young adults who were pregnant, on special diet control and/or having endocrine/metabolic and sleep disorders that affect BMI were excluded. Informed written consent was obtained from the selected young adults. The Ethics review committee of the Faculty of Medical Sciences, University of Sri Jayewardenepura approved the study.

Anthropometric Measurements

Generalized obesity was determined using WHO Asian cutoff of BMI values; they were categorized as Normal (BMI between 18.5 - 22.9 Kg/m^2), Overweight (BMI between 23.0 - 27.4 Kg/m^2), and Obese (BMI over 27.5 Kg/m^2)[20]. Central obesity was measured using the WHO cutoff values of WHR for males and females; (Normal WHR for males was < 0.95 and Normal WHR for females was < 0.8) respectively[21]. A calibrated digital bathroom scale (WS-50-Mirofile, Switzerland) was used to measure weight while a calibrated Stadiometer (KT-GFO6A-Kindcare- China) was used to measure the height of the participant. Body fat percentage (BF%) was estimated by measurement of skin fold thickness of three sites in the body. The sum of the three measurements were used to determine the skin fold thickness for both males and females. A calibrated harpenden skin fold caliper was used to measure the skin fold thickness in abdomen, chest, and mid-thigh were used for males while superior iliac crest, triceps muscle and mid-thigh were used for females

Assessment of Working Memory

Computerized WMs tasks were used to assess the working memory functions and were pretested before using in the study. They were administered using a laptop, following a training session for each young adult. The duration of the test session was about 20 minutes with a 05-minute rest half-way through the test. The order of the administered tests and the resting period was the same for all. A separate room in the Faculty of Allied Health Sciences, General Sir John Kotelawala Defence University was used for testing so as to minimize disturbances. Testing was conducted during the morning session from 8.00 am to 12.00 noon.

Visuospatial Memory task [VSWM]

A pig house with a pig in a 4 ▪4 matrix was displayed on the computer screen with window at a time. The task was to report in reverse order the locations where each target (pig) had appeared. The test started with a span length of two, that is, two pigs appeared one after another. Each span length consisted of two trials, and the test was automatically stopped when the participant failed both trials at the same span length. Each correct location was scored as one point. The total number of points was used as the measure of spatial working memory[26,27].

Verbal Working Memory task [VWM]

Slides with varying numbers of red and blue squares and circles appeared on the screen and the task was to count loudly, the total number of red filled circles, while pointing at the targets, and to keep the total in memory. As soon as the person had counted the number of red circles, he/she was shown the next slide with no time to rehearse. When a slide with question marks appeared, the person had to report the counted totals from the sequence of presented slides in the correct order. The task started with two slides, that is, a span length of two. Each span encompassed three trials. If the participant succeeded in two out of three trials, he/she proceeded to the next span level [26,28].

Statistical Analysis

The data was analyzed by SPSS statistical package (Version 23). Normally distributed data were analysed, using MANOVA followed by independent samples't' test whilst skewed distribution data were analysed using Kruskal Wallis, and Mann Whiteney 'U' test for obtaining differences of means scores. Association between variables was assessed through Pearsons correlation coefficient for normally distributed data whilst Spearmen correlation tests were applied for skewed data. Level of significance was set at $p < 0.05$.

RESULTS

Comparison of demographic factors in obese, overweight vs. normal weight counterparts

There was no significant difference in the distribution of gender, monthly income and education level between normal, overweight and obese categories in the study sample ($\chi^2 = 1.25$, df=2, $\chi^2 = 0.35$, df=4, $\chi^2 = 4.02$, df=4 respectively; $p > 0.05$) (Table 1).

Table 01- Features of the study sample (n=231)

	Normal n=77	Overweight n=77	Obese n=77
	Number (%)	Number (%)	Number (%)
Gender			
Male	38 (31.7%)	38 (31.7%)	44 (36.7%)
Female	39 (35.1%)	39 (35.1%)	33 (29.7%)
Monthly Income (SLR)			
0 - 20000	18 (34.6%)	16 (30.8%)	18 (34.6%)
20001-30000	35 (33.0%)	35 (33.0%)	36 (34.0%)
30001>	24 (32.9%)	26 (35.6%)	23 (31.5%)
Education Level			
Up to GCE O/L	9 (53.0%)	4 (23.5%)	4 (23.5%)
Up to GCE A/L	61 (31.4%)	65 (35.1%)	68 (33.5%)
Up to Degree	7 (35.0%)	5 (25.0%)	8 (40.0%)
	(Mean) (SD)	(Mean) (SD)	(Mean) (SD)
Age (Years)	23.4 (1.6)	23.6 (1.2)	23.2 (1.3)
BMI (Kg/m2)	21.4 (1.5)	25.4 (0.9)	30.7 (4.4)
WHR (Ratio)			
Male	0.94 (.05)	1.01 (.06)	1.06 (.09)
Female	0.76 (.08)	0.83 (.06)	0.94 (.08)

Comparison of working memory tasks in normal, overweight vs. obese individuals

Comparison of means scores of WM tasks in three difference groups as shown in the table 02.

Table 02 – Comparison of means scores of WM and inhibitory tasks between normal vs. overweight and obese

	Normal **n=77** (M) *(SD)*		Overweight **n=77** (M) *(SD)*		Obese n=77 (M) *(SD)*	
WM tasks						
VSWM task	28.6	9.3	23.7	9.8*	21.0	5.2**
Verbal WM task	3.2	0.6	3.1	0.6	2.8	0.6**

**p<0.001, *p<0.05

A significant group effect was observed among BMI groups (normal, overweight and obese) and the performances in WM tasks ($F[4,454] = 10.1$, $p<0.001$). Further, analysis of WM data by students t test revealed that mean scores in VSWM scores were significantly lower amongst obese ($t[152] = 6.26$, $p<0.001$) and overweight subjects ($t[152] = 3.13$, $p<0.05$) when compared with normal BMI subjects. VWM score was significantly lower amongst obese ($t[152] = 3.56$, $p<0.001$) when compared with normal BMI subjects while, mean score in overweight subjects were not significantly different when compared with normal BMI subjects ($p>0.05$) (Table 02). This indicates poor WM amongst the obese and overweight young adults when compared with normal counterparts.

Comparison of WM tasks between normal vs. high WHR categories

Comparison of means scores of WM tasks in difference WHR groups in males and females as shown in the table 03.

Table – 03 Comparison of means scores of WM tasks and inhibitory tasks in difference WHR groups

	M/F	Normal WHR **(M, n=47; F, n= 47)** (M) (SD)		High WHR **(M, n=73; F, n= 64)** (M) (SD)	
WM tasks					
VSWM task	M	27.3	10.9	25.7	9.2
	F	27.2	7.8	18.9	4.3**
VWM task	M	3.2	0.6	2.9	0.6*
	F	3.3	0.7	2.9	0.6**

**p<0.001, *p<0.05

The significantly lower scores were observed in the mean scores of VWM tasks amongst high WHR category males ($t[117] = 2.63$, $p<0.01$) compared with normal WHR males. The mean score of VSWM were not statistically significant in high WHR category males when compared to normal WHR males ($p >0.05$). Furthermore, a significantly lower score was found in the mean scores of VSWM and VWM in females with high WHR (VSWM; $t[109] = 7.10$, $p<0.001$, VWM; $t[109] = 3.83$, $p<0.001$) when compared with normal WHR females. (Table 3).

Associations between WM tasks and body fat percentage in the total sample

There was a significantly positive correlation between BMI and WHR with BF% for both male and female young adults (Male: r= 0.757, r= 0.568, p<0.001; Female: r= 0.783, r= 0.718, p<0.001). Further, a significant negative correlation was observed between VSWM scores and VWM scores with BF% for males and females (VSWM; Male: r= -0.188, Female: r= -0.575, p<0.05; VWM; Male: r= -0.248, Female: r= -0.414, p<0.01).

DISCUSSION

The present study was conducted to determine the association of working memory tasks amongst normal, overweight and obese young adults in a periurban area in Sri Lanka. The normal weight, overweight and obese groups were comparable on their educational status and socioeconomic status. However there was a negative association in working memory tasks amongst obese, overweight and normal weight young adults. The present study provides further support for decreased performance of working memory tasks amongst both generalized obese and centrally obese individuals.

A community based cross sectional study conducted by Gunstad et al. reveled that overweight and obese adults (age 20-50 years) exhibited poorer executive function test performance than normal weight adults which was similar to our findings[13]. Nevertheless, a longitudinal study conducted in USA revealed that higher BMI, waist circumference (WC) and WHR were associated with poorer performance on global cognitive function, memory and language while higher WHR was associated with decreased performance in executive function tasks when compared to normal WHR [15].

To further support to our results, Boeka & Lokkan in 2008 had suggested that lower performances were observed in obese individuals on neuropsychological measures, including the Rey complex figure test (RCFT) and the Wisconsin card sorting test (WCST) which are commonly used as measures of executive functioning[34]. Ariza et al in 2012 revealed the oppose consequences on WM task (Letter number sequences) in middle age obese and healthy individuals in Spain ($p = 0.17$ & $p = 0.40$) respectively[36]. Similar argument which was support to Ariza et al was disclosed by Gonzales et al in 2010 that WM and verbal memory were not significantly difference in normal, overweight and obese categories in middle age individuals (verbal memory; $p = 0.39$, visual memory; $p = 0.48$ & Working memory; $p = 0.79$) respectively[37].

Moreover, our findings revealed that decreased performance of WM and inhibition tasks in high WHR group when compared to normal WHR group for both males and females and further support to this argument by Dore et al in 2008 where waist circumference and WHR were inversely related to multiple cognitive domains with adjustment for age, education and gender[38]. Nevertheless, Nelsson & Nelsson revealed that high WHR young adults were performed decreases in block design test which is used for assessing motor function when compared normal WHR middle age adults in 2009 [39].

However, this study has several limitations. WM dysfunction is one of the many factors that determines the predisposition of the obese and overweight young adults while other confounding were not taken into consideration in the present study. However the results of the present study can cautiously be interpreted that overweight and obesity contributes a certain extent to the WM dysfunction amongst young adults. Further the study was not carried out in a very large population to be applicable to all ethnic groups and the gender distribution too was small. The results warrant further longitudinal studies with an intervention component and would shed light on the contribution of obesity associated WM dysfunction. The results however, provide primary data regarding the association of WM and obesity amongst Sri Lankans.

CONCLUSIONS

Results of the current study has further confirmed the association between deficits in working memory among obese and overweight young adults compared to normal weight subjects in this study population. Future research should seek to further clarify the causality and the cause effect relationship between other working memory tasks and obesity.

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