Scholars Journal of Applied Medical Sciences (SJAMS) **ISSN 2320-6691 (Online)**
Sch. J. App. Med. Sci., 2015; 3(6C):2316-2319 **ISSN 2347-954X (Print)**

(An International Publisher for Academic and Scientific Resources)
www.saspublisher.com

Research Article

Influence of adiposity on neuronal activity related to speed of cognitive processing and perceptual motor function

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Abstract: Obesity is a global health hazard and has been linked to numerous cardiovascular, metabolic, respiratory complications. Recent literature has also documented that obesity has negative impact on the brain. The mechanism for this association is still debatable. So the present study was conducted to assess the association between cognitive function and body mass index as marker of adiposity. The Materials and Methods in The present study included 100 subjects, of which the study group included 50 adults who had Body Mass Index (BMI) more than 30 Kg/ m^2, and 50 non obese adults were enrolled as controls. Choice reaction time was used to assess cognitive function. The results were expressed as mean, standard deviation and data was analyzed using unpaired t test. The results were the mean age of the subjects in the study group was 34.86 whereas in the control group it was 33.38. BMI was significantly higher in the study group as compared to control group ($p < 0.0001$). The results of our study indicated increase in choice reaction time in obese individuals as compared with the normal weight healthy group. In Conclusion the study concluded that there is inverse relationship between adiposity and neuronal activity related to cognitive function.
Keywords: adiposity, cognitive function, choice reaction, neural response.

INTRODUCTION

Obesity is a chronic and debilitating medical condition that results from a complex mix of genetic, physiological, psychological, and social factors. The prevalence of obesity is increasing worldwide and the major causative factors are related to lifestyle changes occurring due to rapid socio-economic transition [1]. Body mass index has been widely accepted as simple marker of adiposity .It is recognized as an instrument which can be used for diagnosing obesity. In adults, obesity is defined as having a body mass index (BMI) of 30.0 kg/height in m^2 or greater [2].

Obesity is associated with an increased risk for numerous chronic health problems including heart disease, Type 2 diabetes, cancer, musculo-skeletal degeneration [3]. Many of the important complications of obesity are linked strongly to intra-abdominal adiposity. Recent literature has also documented that obesity has a negative impact on the brain [4,5]. Studies have suggested that obesity is associated with impaired attention, executive function, and memory not only in patients with co-morbid medical conditions like cerebrovascular pathology, hypertension and diabetes, but also in healthy subjects [6]. This suggests a link between obesity and deficits in neuronal activity, but there is paucity of knowledge regarding exact mechanisms underlying this effect.

Cognition involves brains processing capability which can be assessed by various neurophysiological and neuropsychological tests. Reaction time task acts as a reliable indicator of cognitive function [7]. Reaction time is a psychomotor test, and is an indirect index of processing capability of CNS and simple means of determining sensorimotor association and performance of individual [8]. Choice reaction time is a complicated process in which multiple stimulus is given and the multiple responses are recorded. Choice reaction time involves recognition, discrimination, analysis of stimulus and decision making for appropriate response selection [9]. It measures the speed of cognitive processing of sensory stimuli by brain and its execution in form of motor response, and is a more reliable cognitive test. Delayed or increased choice reaction time indicates deteriorated or improved neuronal activity related to cognitive processes such as attention allocation, analysis and processing of information and executive function.

So, the present study was undertaken to assess neuronal response to visual stimuli in obese individuals in order to determine if any relationships exist between the adiposity and neuronal activity related to speed of cognitive processing and perceptual motor performance.

MATERIALS AND METHODS

Ethical clearance and study population

The present study involved 100 volunteers of both sexes between the age group of 18-60 years. The study subjects were selected on the basis of convenient sampling methodology that was visiting obesity clinic of a Hospital in Ludhiana. Following approval of the ethical committee and due consent, detailed relevant clinical history was obtained from the subjects. This was followed by a brief general and physical examination. Healthy subjects who could follow instructions were included in the study. Subjects with any respiratory, cardiovascular and neurological disorders, drug abuse, and abnormal blood sugar levels were excluded from the study. The purpose and non-invasive nature of the study were explained to each subject, so that the subjects would be in state of calmness.

Anthropometric parameters

Height (meters) and weight (kg) were noted for each subject using standard procedures and instruments. Height (ht) was measured with the subjects standing in an erect posture. Weight was measured using a calibrated weighing machine. These data were used to calculate Body Mass Index (BMI) of each subject. According to WHO, BMI in the range of 18.5 – 24.9 is considered as normal, BMI in the range of 25 – 29.5 is considered as overweight and BMI $\geq$ 30 is considered as obese [10].

Based on the standard WHO criteria for BMI, subjects were divided into 2 groups: study and control group. The study group consisted of 50 obese healthy subjects with BMI more than 30 Kg/ m2 and the control group consisted of 50 healthy non obese subjects with BMI less than 25Kg/ m2.

Waist hip ratio (WHR) was also calculated of each subject. WHR is an index of fat distribution and is used as a marker of abdominal obesity. Waist circumference (WC) was measured at a midpoint between lower border of rib cage and iliac crest. Hip circumference (HC) measurement was done across greater trochanter. WHR was then taken as ratio of WC and HC. A waist/hip ratio of >0.9 in women and >1.0 in men is considered abnormal. It indicates abdominal/central fat accumulation.

Instrument and Recording

Choice reaction time was recorded with help of digital display audiovisual reaction time apparatus (Model no. RTM608), supplied by Medicaid systems, Chandigarh. The instrument is equipped with a sensitive clock which measures time up to 1/10th msec. accuracy of this instrument is + one digit. In the present study choice reaction time in form of visual signals which consisted of 3 light stimuli (red, green and yellow) were used [11].

Each subject was familiarized with the procedure and apparatus. Self-demonstration and three practice trials were given to every volunteer before taking the reading, to help them get conversant with the procedure. The readings of choice reaction were recorded with subject sitting comfortably in the chair. The examiner sat on the master control and the subject on the other side with secondary controls. The two controls were separated with an opaque partition in order to avoid seeing which switch is being pressed by the examiner. Any one of the three visual signals for light i.e. red, green and yellow light were presented randomly by the observer. The subject was asked to respond immediately to above stimuli i.e. flashing of light by pressing the off switch knob of digital display apparatus, to switch off the produced light. Reaction time displayed on auto display was noted. 3 readings of each stimulus were noted and the lowest was taken as the reading for each stimuli.

Statistical Analysis

The recorded data were transferred to an MS- excel sheet and statistical analysis was carried out using Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, version 13.0 for Windows). Results were expressed as mean and standard deviation. The data was analyzed using unpaired t test. All statistical tests were two sided and performed at a significance level of 0.05

RESULTS

In the present study, the study and control group were well matched for age and sex indicating the samples were homogenous in this respect, and were comparable for the study, as Shown in table 1. The mean age of the subjects in the study group was 34.86 whereas in the control group it was 33.38.

Table-1: Distribution of subjects according to age and sex

Parameters	Control (N = 50)		Study (N = 50)	
Age (years)	34.86 ±10.24		33.38 ±8.73	
Gender	N = 50	%age	N = 50	%age
Male	18	36%	14	28%
Female	32	64%	36	72%

BMI and WHR

In the present study, the mean body mass index of the study group was 34.25 ± 3.13 and of the control group was 23.78 ± 2.06. BMI was significantly higher in the study group as compared to control group ($p < 0.0001$). The mean WHR of study group (0.93± 0.14) was also significantly ($p < 0.0001$) higher than control group (0.84 ± 0.04), as shown in Table 2.

Table-2: Mean BMI and waist hip ratio comparison of control and study group

Variable	Control Group MEAN ±SD	Study group MEAN ±SD	P value
BMI (Kg/m^2)	23.78±2.06	34.25± 3.13	< 0.0001 * *
WHR	0.84 ± 0.04	0.93±0.14	< 0.0001 * *

*** * = Highly Significant**

Visual Reaction Time

In the present study, Visual reaction time was increased in obese subjects than non-obese controls and was statistically significant for yellow color (Table 3). However, for red and green color, the findings were statistically insignificant.

Table- 3: Comparison of mean ±S D values of choice reaction time to visual stimuli in control and study group

Variable	Control (N= 100) Mean ±SD	Study (N= 100) Mean ±SD	T value	P value
Yellow	0.33±0.14	0.42±0.12	3.27	< 0.001* *
Red	0.39±0.15	0.43±0.08	1.37	>0.05 NS
Green	0.39±0.18	0.41±0.11	0.62	>0.05 NS

NS = Non Significant *** * = Highly Significant**

DISCUSSION

The present study was planned to evaluate association of adiposity with cognitive function using choice reaction time task. The results of our study indicated prolonged choice reaction time in obese individuals as compared with the normal weight healthy group. Hence, the results of our study suggested that, there is an inverse relationship between adiposity and neuronal activity related to cognitive processes such as attention, processing speed and motor performance. Findings similar to ours have been suggested by other studies [12, 13].

Literature indicates that, obesity alone as well as in association with other co morbidities predispose to poor neurological outcome [14]. Studies have documented that elevated BMI is associated with impairment in various cognitive functions especially, attention, memory deficits, executive function, all of which may affect speed of cognitive processing and perceptual motor performance [15, 16]. The exact reasons underlying association between obesity and cognitive decline have not been exactly identified; we can offer certain mechanisms which could provide speculative explanations for obesity resulting in poor cognition.

The responsiveness of CNS to stimuli may decline in obese because of impairment in attention and mental flexibility in obese subjects which influences the speed of mental processing and hence response time [17]. Another potential mechanism could be that since larger body mass require more blood flow for proper functioning, so, lack of essential blood flow in obese may be a contributing factor to poor cognitive performance [18]. Decreased blood flow might result in poor cognition, due to decreased supply of necessary nutrients like glucose and oxygen. Studies have shown decreased blood flow in prefrontal cortex in subjects having higher body mass index, this could potentially result in negative impact of obesity on the cognitive function [19]. Neuroimaging studies have linked obesity to various structural and functional changes including reduced blood flow in frontal regions, greater atrophy, development of white matter hyper intensities in frontal regions and reduced neural connectivity which are likely to affect cognition [20]. Another possible mechanism postulated on the underlying mechanism could be attributed to obesity being associated with various pathophysiological changes including vascular changes, systemic inflammation, impaired insulin regulation, with a potential to negatively influence executive function via the vascular pathway resulting in altered brain function and cognition [21].

Adipocytes secrete certain hormones, pro-inflammatory cytokine, chemokines and tissue necrosis factor that can cross blood brain barrier and may alter brain function [22]. Abnormal levels of adipokines can result in disrupted myelination. One potential consequence of disrupted myelination would be altered axonal transmission and interruptions in neurological function. Studies have also indicated that the reduced perceptual motor performance in obese could be simple physical slowness as a result of fattening [23]. It is also likely that the neuropathies occurring in obese can reduce speed of impulse conduction of both sensory and motor nerves, resulting in alteration of brain activation during a cognitive challenge and hence, a delayed motor performance.

Thus, it is concluded that obesity is associated with reduction in cognitive processing and perceptual motor performance. Our study indicates that, obese

individuals even in absence of co morbidities have poor cognitive function potentially, leading to future negative impact of obesity on the brain health. These findings highlight the need for weight control to reduce the risk of future adverse neurological outcome. Lifestyle modifications such as dietary control and exercise should be advised and incorporated at earliest stage in obese in order to halt the onset and progression of future adverse neurological clinical manifestations.

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