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A comparative study of audio and visual reaction time in obese and non-obese subjects

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ABSTRACT

Background: Reaction time provides indirect index of processing capability of CNS and also a means of determining sensorimotor performance. The present study was undertaken to study and compare audio and visual reaction time in healthy obese subjects with non-obese subjects. **Aims and Objectives:** This prospective study was undertaken to find out whether obesity in otherwise healthy individuals is associated with any alteration in auditory and visual reaction time. **Materials and Methods:** The study involved 100 subjects 50 obese (cases) and 50 non-obese (control) of both sexes within age group 18-60 years. The Anthropometric parameters under study are height in meters, weight in kg to calculate BMI. Then we measured auditory reaction time (ART) and visual reaction time (VRT) and compared in 2 groups. This comparative study was carried out in Dr. S.C.G.M.C, Vishnupuri, Nanded. **Results:** We have found that auditory and visual reaction time was longer in obese subjects than non-obese control. There was a significant increase in ($P<0.05$) ART to sufficient sound and significant increase in VRT($P<0.001$) to yellow color. **Conclusion:** We conclude that there is evidence of sensory motor slowing and delay in CNS processing in obesity as suggested by increased reaction time to audiovisual stimuli.

Key words: Body mass index; Obesity; Central nervous system; Audiovisual reaction time

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INTRODUCTION

Obesity is a global epidemic and has been found to be associated with multiple health problems that include hypertension, cardiovascular disease, type 2 diabetes mellitus and respiratory disease etc. According to a global estimate by the World Health Organization (WHO), approximately 400 million adults were obese globally in 2005.[1] With rapid urbanization and increase in sedentary life style of individuals these numbers are expected to rise to more than 700 million in next decade. Though it's a well-known fact that obesity is associated with increased risk of chronic systemic diseases even in healthy individuals' obesity is associated with slowing of audiovisual reaction time.[2]

Reaction time is the time interval between the onset of stimulus and initiation of response under the condition that the subject is instructed to respond as rapidly as possible. Reaction time study is excellent example of task which comprises both are sensory and motor component and processing in CNS.[3] It can be used as an indirect index of processing capability of nervous system and can be easily assessed. Various factors such as age, chronic diseases, mental stress, socioeconomic status and body mass index are some of the factors known to affect reaction time. It determines alertness, stimulus processing, decision making and response programming.[4]

Both central and peripheral nervous system are involved in development of obesity and its various complications. A number of studies have reported the mechanism of development of obesity and its consequences on metabolic, cardiovascular and respiratory physiology.[5] The impact of obesity on central nervous system (CNS) processing appears to be profound. The mechanism by which obesity affects audiovisual reaction time by altering integrated

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coordination between afferent (sensory) and efferent nerves (motor) still needs to be explored.[6]

Some Experimental data have indicated that CNS may also be affected by obesity leading to cognitive decline and dementia. Various neurophysiological studies have shown that greater BMI is associated with reduced cognitive performance especially in areas of attention, execution and memory. This provides a possible physiological explanation for obesity influencing reaction time, but the knowledge in the field remains incomplete. There are many randomized controlled trials which have concluded that obesity, particularly in adult individuals, does have an adverse impact on audiovisual reaction time. On the contrary the effect of childhood obesity on audiovisual reaction time remains somewhat controversial. Increase in reaction time in healthy adult obese individuals has been attributed to nerve conduction slowing and small fiber neuropathy by some authors.[7] This theory has been substantiated by findings of nerve conduction velocities in obese individuals. In addition to this obesity is also known to be associated with changes such as insulin resistance, systemic inflammation and vasculopathy which may be responsible for additional damage to neuronal function thereby impairing reaction time. Another theory which is put forward by some scholars include presence of abnormal levels of adipokines causing myelination abnormalities thereby causing delayed transmission of neuronal signals which may in turn be responsible for increased reaction time in healthy obese individuals.[8]

With this background we conducted this comparative study to analyze whether obesity in otherwise healthy individuals is associated with any alteration in auditory and visual reaction time.

MATERIALS AND METHODS

The present study was carried out in the department of Physiology, Dr. S. C. Government medical college Vishnupuri, Nanded. Approval for the study was taken from the institutional ethical committee. The study involved 100 volunteers of both sexes within age group of 18-60 years. Anthropometric parameters such as height (meters) and weight (kg) were noted for each subject. This data was used to calculate Body mass index (BMI) Of each subject as per Quetelet's index.[9]

$$\text{Body Mass Index} = \frac{\text{Weight (Kilogram)}}{\text{Height}^2\text{ (meter)}}$$

The individuals were divided into having a normal weight (18.5-24.9 kg/m^2) or being obese (> 30 kg/m^2) on the basis of body mass index. Individuals between BMI of 25-30 (overweight) were excluded from the study. The study group consisted of 50 obese healthy subjects with BMI more than 30 Kg/ m^2 and the control group consisted of 50 healthy non obese subjects with BMI less than 25Kg/ m^2.

At the start of study, details of history and examination were recorded on proforma of all volunteers. Random Blood Sugar (RBS) was done by glucometer in all the volunteers and those with abnormal RBS were excluded from the study. Subjects with any major medical illness which might affect reaction time were excluded from the study. The purpose, procedure and non-invasive nature of the study were explained and written informed consent was taken from each subject.

Reaction time (RT) was recorded with help of digital display audiovisual reaction time apparatus (Model no. RTM608) supplied by Medicaid Systems, the instrument was equipped with a sensitive clock which measures time up to 1/10th msec. Accuracy of this instrument is + one digit. Audiovisual reaction time apparatus was equipped with 3 light stimuli (red, green and yellow) and auditory stimuli in form of a continuous beep on the speaker (low frequency -500 Hz and high frequency -1 KHz sounds).

Each volunteer was familiarized with the procedure and apparatus so that they were in a state of calmness at the time of the test. 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 auditory reaction time (ART) and visual reaction time (VRT) were recorded in a quiet room with subject sitting comfortably in the chair. The visual and auditory signals were presented randomly by the observer and subjects were instructed to respond to the stimuli immediately by pressing appropriate switch off knob on the panel to stop the clock of the apparatus. For measuring VRT, any one of three stimuli for light i.e., red, green and yellow light were presented randomly and the subjects were asked to respond to the flashing of light as rapidly as possible. For ART, high and low frequency sounds were presented randomly and subjects responded by switching off the produced sound signal immediately. Reaction time displayed on the auto-display was noted. 3 readings of each stimulus were noted and the lowest was taken as the reaction time. The data was expressed as mean + SD. Results were then analyzed using "ANOVA test". For statistical purposes p value less than 0.05 was taken as statistically significant.

RESULTS

Out of total 100 studied cases there were there were 32 females and 18 males in control group whereas in study group there were 36 females and 14 males. The gender distribution of the studied cases was found to be comparable with no statistically significant difference (P>0.05) (Figure 1).

The mean age of control group was found to be 34.86+10.24 years whereas the mean age of individuals in test group was found to be 33.38+8.73 years. The mean age of both the groups was found to be comparable with no statistically significant difference (P=0.3486) (Table 1).

The mean BMI of the individuals in control group was found to be 23.78+/- 2.06 Kg/m2 whereas the mean BMI of individuals in test group was found to be 34.25+/- 3.13 Kg/m2. Individuals in test group had a higher BMI as compared to control group and the difference was statistically highly significant (P<0.0001) (Table 2).

Three stimuli for light i.e., red, green and yellow light were presented randomly to the individuals in control as well as study group and mean reaction time for all the 3 colors was calculated in both the groups. There was a significant difference in visual reaction time for yellow color (P<0.05) in studied groups whereas visual reaction time was found to be comparable for red as well as green color (P>0.05) (Table 3).

There was a significant difference in auditory reaction time for high frequency sound (P<0.05) in studied groups whereas auditory reaction time for low frequency sound was found to be comparable in both the groups with no statistically significant difference (P>0.05) (Table 4).

DISCUSSION

Reaction time is indirect index of processing capability of CNS and a simple means of determining sensorimotor coordination. Reaction time means time interval between the onset of the stimulus and the initiation of the response under the condition that the subject has been instructed to respond as rapidly as possible. Reaction time measurement includes the latency in sensory neural code traversing peripheral and central pathways, perceptive and cognitive processing, motor signal traversing both central and peripheral neuronal structures and finally latency in end effector activation (i.e., muscle activation). So, any change in reaction time indicates presence of a peripheral and/or central disturbance.

The results of our study indicated increase in visual and auditory reaction time in healthy obese individuals as compared with the non-obese. Results similar to our study have been reported by the other authors as well. Deore DN et al conducted a study to analyze the relationship between the Body Mass Index (BMI) and the audiovisual reaction time in young healthy females. The authors found that There was a prolongation of both ART and VRT in the underweight and the overweight individuals.[10] Similar findings were also reported by the authors such as Reigal RE et al. However other authors such as Esmaeilzadeh S et al found that information processing speed in healthy

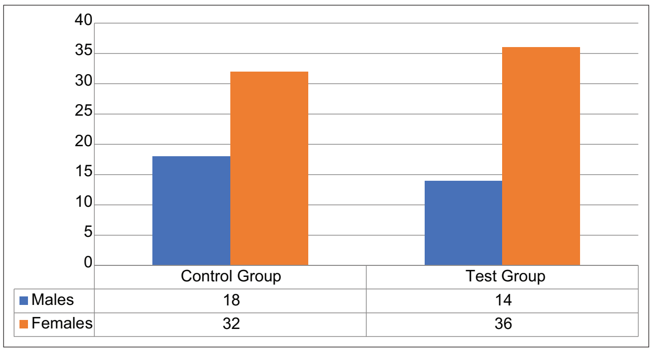

Figure 1: Gender Distribution of the studied cases.

Table 1: Comparison of mean age in control and study group

	Mean age (Years)	Std deviation	
Control group	34.86	10.24	P= 0.3486
Test group	33.38	8.73	Not Significant

Table 2: Comparison of BMI in control and study group

	Mean BMI (kg/m²)	Std deviation	
Control group	23.78	2.06	<0.0001
Test group	34.25	3.13	Highly Significant

Table 3: Comparison of visual reaction time in control and study group

Variable	Control group	Study group	P value
Red	0.39±0.15	0.43±0.08	P=0.0994 Not Significant
Green	0.39±0.18	0.41±0.11	P=0.5042 Not Significant
Yellow	0.33±0.14	0.42±0.12	P=0.0008 Significant

Table 4: Comparison of auditory reaction time in control and study group

Variable	Control group	Study group	P value
High Frequency sound	0.49±0.15	0.56±0.17	P=0.0314 Significant
Low Frequency sound	0.59±0.24	0.58±0.20	P=0.8214 Not Significant

obese individuals was comparable to healthy individuals having normal BMI.[11]

It is likely that obese perform poorly because obesity produces deficit in response inhibition resulting in increased response time. Literature indicates that obesity alone as well as in association with other risk factors predisposes to future neurological complications.[12] Nerve conduction studies have been used to suggest that obese have an increased risk for developing nerve conduction slowing and small sensory fiber neuropathy due to increase sensory threshold which could be expected to alter reaction time. In this regard Buschbacher RM et al found that sensory and mixed nerve amplitudes correlated significantly ($P <$ or $= 0.01$) with BMI for all nerves tested, with means being approximately 20-40% lower in the obese than in the thin subjects.[13]

In one of the studies, authors have suggested that low level of BMI is associated with shorter reaction time. Significant improvement in motor performance has also been observed in healthy overweight women following weight reduction. There is growing evidence that obesity is associated with poor neurocognitive outcome but exact reasons for the underlying association remain unclear, we can offer speculative explanations. Various neurophysiological studies have shown that brain regions involved in cognition, memory, reasoning, processing speed and sensorimotor performance are influenced by BMI in both young and middle-aged adults all of which are likely to affect reaction time. Many significant findings have indicated impairment in attention and mental flexibility due to altered inhibition capacity in obese which can influence the speed of mental processing and response time.[14] Obesity is also associated with various pathophysiological changes including vascular changes, systemic inflammation, impaired insulin regulation, all of which can influence executive function via the vascular pathway. Another mechanism suggested is that adipose tissue secrete cytokines, chemokines and tissue necrosis factor that can cross blood brain barrier and may alter brain function. Abnormal levels of adipokines result in abnormalities in myelination. One potential consequence of disrupted myelination is altered axonal transmission. Hence neuronal or myelin abnormalities along with axonal degeneration might be responsible for prolongation of reaction time.[15]

In our study, the cause for significant increase in VRT for yellow color and nonsignificant increase for red and green is uncertain, but can be explained on the basis of trichromatic theory of color vision. According to this theory yellow color has a smaller number of cones as compared to red so it is stimulated less. The cause for significant increase in ART for high pitch could be attributed to reduction of task force in choice reaction time tasks.

CONCLUSION

The results of present study thus conclude that there is indication for certain amount of sensorimotor slowing and delay in CNS processing in obesity as suggested by increase in reaction time. This could be due to impairment in cognitive domains like attention and executive functions, vascular changes, myelin abnormalities along with axonal degeneration.

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Author's Contribution:
AM-Concept and design of the study; interpreted the results, prepared first draft of manuscript and critical revision of the manuscript; **AA-**Statistically analyzed and interpreted; reviewed the literature and manuscript preparation.

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