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RESEARCH ARTICLE

# Visual and brainstem auditory evoked potentials in obese and overweight individuals

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## ABSTRACT

**Background:** Overweight and obesity are known to be associated with major health risks. Their detrimental effects on central nervous system (CNS) have begun to be appreciated too. The data for cranial nerve involvement and CNS conduction delays, however, are still sparse. **Aims and Objectives:** The study intended to assess the extent of influence by recording pattern reversal visual evoked potential (PRVEP) and brainstem auditory evoked potential (BAEP) in overweight and obese individuals. **Materials and Methods:** PRVEP and BAEP were recorded in 85 individuals (30 obese, 30 overweight, and 25 controls) in the age group of 18-70 years. Indian-specific body mass index (BMI) cutoff points (controls: BMI <23, overweight: BMI 23-25, and obese: BMI >25) were used for classifying the individuals. PRVEP P100 latency and N75-P100 amplitude and BAEP absolute and interpeak latencies were compared among the three groups using one-way ANOVA and Tukey's multiple comparison tests. $P < 0.05$ was considered statistically significant. **Results:** Statistically significant prolongation of PRVEP P100 latency ($P < 0.01$), BAEP absolute latency of wave III and V ($P < 0.0001$), and interpeak latencies I-III and I-V ($P < 0.001$) was obtained in obese and overweight individuals as compared to the controls with no significant alteration in N75-P100 amplitude among the three groups ($P > 0.05$). **Conclusion:** Overweight and obesity document derangements in visual evoked potentials and BAEPs, indicating CNS conduction delays with brainstem as well as cerebral cortical involvement. The influence of raised BMI (BMI >23) can affect the clinical interpretation of these tests.

**KEY WORDS:** Obese; Overweight; Brainstem Auditory Evoked Potentials; Visual Evoked Potentials

## INTRODUCTION

Obesity has become a major global health challenge owing to its established health risks and substantial increase in the prevalence in various parts of the world. Overweight and obesity are emerging as one of the most common, yet among the most neglected public health problems. The prevalence rates have increased not only in the developed but also in the developing countries. Both the genders and wide spectrum of age groups are involved. India has been reported to be just behind the US and China in this global hazard list of top 10 countries with highest number of obese people. The USA accounted for 13% of obese people worldwide in 2013, with China and India jointly accounting for another 15% with 30 million obese individuals in India.[1] In urban North Indian population, the prevalence of obesity has been stated as 5.5% in males and 12.6% in females.[2] In another study from Indian population, the prevalence of obesity was found to be 31.3% among the residents of Chandigarh.[3]

Body mass index (BMI) provides the most useful and practical indicator of overweight and obesity at the population level.

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According to the World Health Organization (WHO), a BMI of 30 kg/m$^2$ or above denotes obesity and that of 25 or above is overweight. However, population-specific BMI cutoff points have been suggested for obesity as different ethnic groups have been shown to differ in BMI with same level of body fat, age, and gender; therefore, the health risks increase below the cutoff point of 25 kg/m$^2$ that defines overweight in the current WHO classification.[4] Ethnic-specific BMI cutoff values, especially for Asian populations, have been proposed to address the higher prevalence of diabetes and cardiovascular diseases and the differing associations of BMI with body fat in different populations.[5-9] Recent studies using Indian-specific criteria for overweight (BMI >23), obesity (BMI >25), and abdominal obesity (WC >90 cm in men and >80 cm in women) have found the prevalence rates among Asian Indians exceeding those in the US population.[10] Guidelines for obesity and overweight based on body mass indices (BMI) for Asian Indians were revised based on consensus developed through discussions by a prevention and management of obesity and metabolic syndrome group.[11]

Although the consequences and health risks of obesity on metabolic and cardiovascular physiology are well established, there is a growing appreciation that the complications of obesity also extend to the central nervous system (CNS). The experimental data have now begun to establish its detrimental effects on the brain.[12,13] Experimental animal models as well as imaging studies in humans have revealed the changes in white matter and lipid composition of myelin in association with obesity.[12,14-17] In addition, it has been suggested that the amount of body fat can also contribute to the adipose tissue in the epineurium to some extent.[18] In this regard, BMI can be hypothesized as an important variable that can affect the conduction time in peripheral and CNS. Documentation of such dysfunctions in peripheral motor and sensory nerves in nerve conduction studies is available, yet a paucity of records for cranial nerve involvement in obese and overweight individuals persists.[18-21] Hence, the present study was planned to evaluate the CNS conduction by recording pattern reversal visual evoked potential (PRVEP) and brainstem auditory evoked potential (BAEP) in overweight and obese individuals.

## MATERIALS AND METHODS

BAEP and PRVEP were recorded in 85 healthy adults (30 obese, 30 overweight, and 25 age- and sex-matched controls) in the age group of 18-70 years (mean age: 43.38 ± 11.8 years). The tests were performed in electrophysiology laboratory in the Department of Physiology, Maharishi Markandeshwar Institute of Medical Sciences and Research, Mullana, Ambala. The approval from the Institutional Ethics committee was taken to carry out the research work. A complete neuro-otological and ophthalmological examination of each individual was done after obtaining written informed consent and a detailed clinical history. The height (cms) and weight (kgs) of the individuals were measured as a part of the general examination and BMI calculated as weight (kg)/height (m$^2$).

Inclusion criteria for the study were adult healthy controls in the age group of 18-70 years while individuals with metabolic, endocrine, demyelinating pathologies, abnormal otological, and ophthalmological examinations were excluded from the study. Indian-specific BMI cutoff points were used for the selection of the individuals (controls with BMI <23, overweight with BMI 23-25, and obese with BMI >25).[11,22]

BAEP recording was done on Allengers Scorpio - EMG, EP, and NCS. Standard disc surface electrodes were placed according to the International 10/20 system of electrode placement, with active electrode at Mi, reference electrode at Cz, and ground electrode at Fpz.[23] Monaural auditory stimulus with rarefaction clicks (0.1 ms pulse) was provided. Click intensity of 80 dB nHL was delivered through headphones at a rate of 11.1/s. The contralateral ear was masked with white noise 30 dB below the BAEP stimulus. The low filter setting was adjusted at 100 Hz and high filter setting at 3000 Hz. Responses to 2000 click presentations were averaged to obtain a single BAEP waveform pattern. Two such responses were superimposed to ensure the reproducibility. Parameters for the study were absolute latencies of wave I, III, and V and interpeak latencies I-III, III-V, and I-V.

PRVEP was performed on Allengers Scorpio - EMG, EP, and NCS. Individuals were seated about 95 cm away from a video monitor with a 30 cm screen. The video monitor presented a black and white checkerboard pattern with a fixation spot in the center of the screen (mean luminance 50 candela/m$^2$ and contrast 70%). The checks reversed alternately at the rate of 2 Hz. The visual angle subtended by the checks and that by the screen were 54.6 min and 19°, respectively. The signals were amplified and filtered with a system band pass filter of 2-100 Hz and 100 responses were averaged. Standard disc surface electrodes were placed according to the International 10/20 system of electrode placement, with active electrode at Oz, reference electrode at Fz and ground electrode at Fpz.[23] Monocular stimulation was done. To validate the reproducibility of the waveform, two responses were recorded and superimposed. Parameters for the study were P100 latency and N75-P100 amplitude. All the data were expressed as mean ± standard deviation. The parameters were compared and analyzed among the three groups (controls, overweight, and obese) using one-way ANOVA and Tukey's multiple comparison tests. $P < 0.05$ was considered statistically significant.

## RESULTS

Mean ages among controls, overweight, and obese (41.04 ± 13.08 years, 43.93 ± 11.72 years, and

44.33 ± 10.53 years, respectively) and mean head sizes (33.28 ± 1.14 cm, 33.45±1.42 cm, and 33.35 ± 1.35 cm) in the three groups were not statistically significantly different ($P > 0.05$) while $P < 0.05$ for the differences in the mean BMI (kg/m$^2$) among the three groups (21.29 ± 1.56, 24.02 ± 1.01, and 30.68 ± 3.82, respectively) (Figure 1). BAEP absolute and interpeak latency comparisons among controls, overweight, and obese individuals revealed that mean BAEP absolute latency for wave IIII and V varied significantly with $P < 0.0001$ among the three groups (for both right and left ears) by one-way ANOVA and mean BAEP interpeak latencies I-III and I-V varied significantly with $P < 0.001$ (Tables 1 and 2). Within -group comparison revealed that the statistical significance for the increase in latencies existed between controls and overweight ($P < 0.01$) and that between controls and obese groups ($P < 0.01$) for both absolute and interpeak latency comparisons (*post hoc* test). PRVEP mean P100 latency comparisons among controls, overweight, and obese revealed significant differences too ($P < 0.01$) by one-way ANOVA for both the eyes, with significant increase found for overweight as compared to controls and also for obese when compared to controls (*post hoc* test). N75-P100 amplitude differences among the three groups did not exhibit statistical significance ($P > 0.05$) (Table 3).

## DISCUSSION

Obesity-induced CNS alterations are of particular interest for the researchers. Peripheral motor and sensory nerve conduction defects have been documented in the past studies.[18-21] Reports for cranial nerve involvement and the conduction delays in the CNS are scarcer. In an attempt to find out changes in the CNS conduction, brainstem auditory and visual evoked potentials were recorded in the overweight and obese individuals.

The study reports prolongation of BAEP absolute latencies III and V and interpeak latencies I-III and I-V (for both ears) (Tables 1 and 2) (Figure 2). PRVEP P100 latencies also exhibited prolongation (for both eyes) in obese and overweight individuals as compared to the controls (Table 3 and Figure 3). The results suggest conduction delays in the auditory and visual pathways supporting brainstem as well

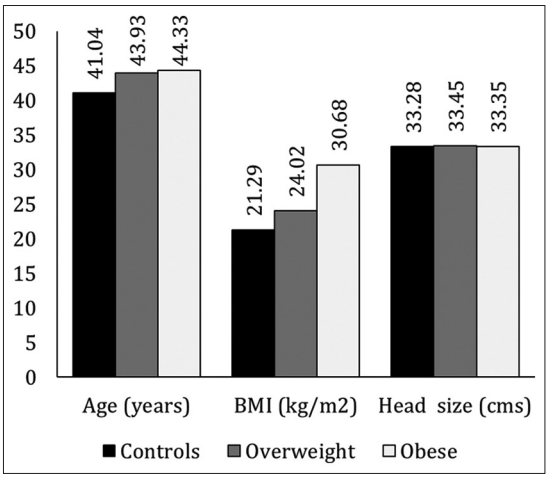


**Figure 1:** Demographic and anthropometric data compared among controls, overweight, and obese

**Table 1:** Mean BAEP absolute latencies among controls, overweight, and obese

| Groups | Number of individuals | Ms±SD | | | | | |
|---|---|---|---|---|---|---|---|
| | | Mean BAEP absolute latency Wave I | | Mean BAEP absolute latency Wave III | | Mean BAEP absolute latency Wave V | |
| | | R | L | R* | L* | R* | L* |
| Controls | 25 (M=13, F=12) | 1.72±0.09 | 1.74±0.07 | 3.65±0.08 | 3.66±0.13 | 5.67±0.1 | 5.69±0.09 |
| Overweight | 30 (M=14, F=16) | 1.74±0.11 | 1.73±0.1 | 3.79±0.1 | 3.81±0.1 | 5.84±0.12 | 5.82±0.13 |
| Obese | 30 (M=13, F=17) | 1.75±0.1 | 1.72±0.11 | 3.81±0.12 | 3.8±0.14 | 5.9±0.09 | 5.88±0.14 |

R: Right ear, L: Left ear, M: Males, F: Females. *$P$<0.0001 for comparison between the three groups by one-way ANOVA. The statistical significance for the increase in the absolute latencies existed between controls and overweight and that between controls and obese (*post-hoc* test). BAEP: Brainstem auditory evoked potential, SD: Standard deviation

**Table 2:** Mean BAEP interpeak latencies among controls, overweight, and obese

| Groups | Number of individuals | Ms±SD | | | | | |
|---|---|---|---|---|---|---|---|
| | | Mean BAEP interpeak latency I-III | | Mean BAEP interpeak latency III-V | | Mean BAEP interpeak latency I-V | |
| | | R* | L* | R | L | R* | L* |
| Controls | 25 (M=13, F=12) | 1.92±0.12 | 1.92±0.14 | 2.09±0.4 | 2.09±0.39 | 3.95±0.1 | 3.87±0.4 |
| Overweight | 30 (M=14, F=16) | 2.06±0.15 | 2.08±0.14 | 2.04±0.13 | 2.01±0.16 | 4.09±0.18 | 4.09±0.19 |
| Obese | 30 (M=13, F=17) | 2.06±0.1 | 2.08±0.13 | 2.1±0.14 | 2.09±0.19 | 4.15±0.13 | 4.16±0.16 |

R: Right ear, L: Left ear, M: Males, F: Females. *$P$<0.001 for comparison between the three groups by one-way ANOVA. The statistical significance for the increase in the interpeak latencies existed between controls and overweight and that between controls and obese (*post-hoc* test). BAEP: Brainstem auditory evoked potential, SD: Standard deviation

**Table 3:** Mean PRVEP P100 latency and mean N75-P100 amplitude among controls, overweight, and obese

| Groups | Number of individuals | Mean P100 latency (ms±SD) | | Mean N75-P100 amplitude (μv±SD) | |
|---|---|---|---|---|---|
| | | R* | L* | R | L |
| Controls | 25 (M=13, F=12) | 104.46±3.22 | 104.57±3.24 | 5.29±2 | 5.13±2.05 |
| Overweight | 30 (M=14, F=16) | 108.36±4.84 | 108.43±6.05 | 4.23±2.6 | 4.28±2.53 |
| Obese | 30 (M=13, F=17) | 109.35±4.96 | 108.4±5.02 | 5.2±1.98 | 5.15±2.05 |

R: Right eye, L: Left eye, M: Males, F: Females. *$P$<0.01 for the comparison between the three groups by one-way ANOVA. The statistical significance for the increase in mean P100 latencies existed between controls and overweight and that between controls and obese (*post-hoc* test). PRVEP: Pattern reversal visual evoked potential, SD: Standard deviation

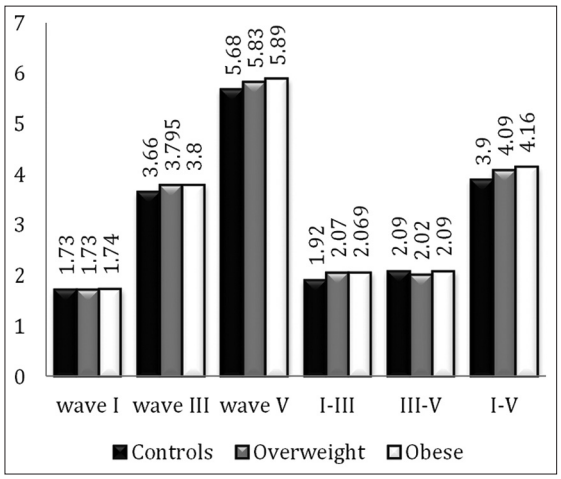


**Figure 2:** Mean brainstem auditory evoked potential absolute and interpeak latencies (mean of right and left ear) (ms ± standard deviation) among controls, overweight, and obese

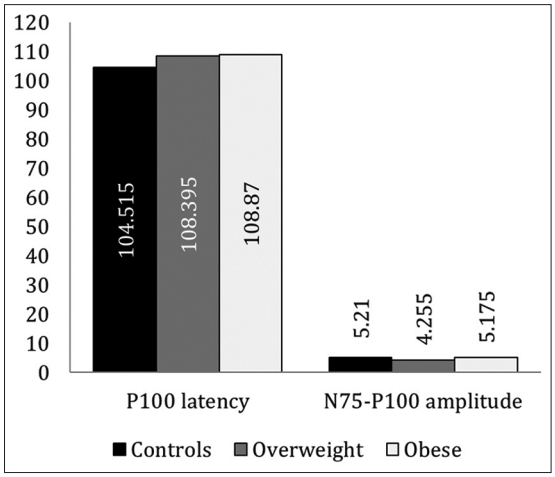


**Figure 3:** Mean pattern reversal visual evoked potential P100 latency (ms ± standard deviation [SD]) and mean N75-P100 amplitude (μv ± SD) (mean of right and left eyes) among controls, overweight, and obese

as cerebral cortical affection. The present study findings comply with some previous similar studies.[24-26] Solanki et al. (2012) in their study emphasized BMI as an important variable influencing BAEP records.[24] Subramaniam et al. (2013) who performed auditory evoked potentials in obese adults found increase in the absolute latencies of waves I, III, and V but interpeak latencies differences could not be found as significant.[26]

The conduction delay found in overweight and obese individuals in the present study can be explained by the fact that obesity is considered as a state of low-grade chronic inflammation with hypoxia as the triggering factors inducing inflammatory cytokine secretion such as tumor necrosis factor-alpha, interleukin-1 (IL-1), and IL-6 by the adipose tissues.[27-30] These cytokines are potent stimulators for the production of reactive oxygen species (ROS) by macrophages and monocytes; therefore, a rise in the concentration of cytokines could be responsible for the increased oxidative stress. Adipose tissue also has the secretory capacity of angiotensin II, which stimulates nicotinamide adenine dinucleotide phosphate (NADPH) oxidase activity. NADPH oxidase comprises the major route for ROS production in adipocytes.[31,32] The consequences of increased oxidative stress are neuronal and Schwann cell damage.[33,34] Decreased overall levels of myelin described in experimental animal models as well as in imaging studies in humans depicting white matter changes and neuronal and/or myelin abnormalities in association with obesity are in support of the above facts.[14,17] An obvious consequence of altered myelination is altered synaptic transmissions.

## CONCLUSION

Visual evoked potentials and BAEPs both document derangements in obese and overweight individuals, indicating CNS conduction delays with brainstem as well as cerebral cortical involvement. The influence of raised BMI (BMI >23) should be borne in mind during clinical interpretation of these tests. Researches investigating actual molecular and biochemical changes in obese to elaborate and strengthen the CNS involvement in obesity are warranted in the future.

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