# Influence of BMI and head circumference on variables of auditory evoked potential in young healthy male human participants

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**Context**
Age, hearing loss, sex, BMI, and head size are very important parameters that influence auditory evoked potential (AEP) variables. Although the correlation of BMI and head size with AEP parameters has been studied recently, there is no common consensus on it. A few studies show a positive correlation, whereas others report a weaker correlation. Further, normative values of the V/I ratio also show a wide range of normative values from different studies.

**Aims and objectives**
This study aimed to evaluate the association of AEP variables with BMI and head size in healthy young male participants and to collect normative data for the V/I amplitude ratio.

**Materials and methods**
This is a cross-sectional study in which 30 young healthy male participants with age range 19–25 years and BMI range 15–26 kg/m$^2$ underwent AEP testing. All were screened for inclusion and exclusion criteria established for the study. Informed consent was obtained and the data obtained were stored in an Excel sheet. A simple correlation regression coefficient was obtained between physical parameters and different AEP variables.

**Results**
We observed a strong positive correlation between head size and V wave latency ($r = 0.5$) and a weaker positive correlation between head size and AEP interpeak latencies (IPLs) I–V and III–V ($r = 0.3$). No correlation was observed between BMI and AEP variables. The V/I amplitude ratio was 0.98 ± 0.68 and 0.93 ± 0.7 for the left and the right ear, respectively.

**Conclusion**
We concluded that BMI had no influence, and head size showed an association with AEP outcome, especially V wave latency and the AEP–IPL difference. The V/I ratio needs to be examined further in studies with larger sample sizes as values were different from those of previous studies.

**Keywords:**
auditory evoked potential, BMI, head size, interpeak latency

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## Introduction

Auditory evoked potentials (AEP) are recorded from the scalp as small voltage potentials after passing auditory stimuli through a headphone [1]. There are mainly five AEP waveforms. These waves represent the neuroelectrical activity that is generated by the neural generators in the auditory pathway between the cochlea and the brainstem. Among the various factors that affect AEP, age and hearing loss with definitive prolongation of absolute peak AEP latencies are well established [2]. The effect of sex on brainstem auditory evoked response (BAER) absolute peak latencies (APL) and interpeak latency (IPL) difference showed nonsignificant differences between 3 and 13 years, wheras between 16 and 45 years, sex differences were evident. These differences can be attributed to hormonal factors, temperature variations, and anthropometric component (head size) [3,4]. In a few studies, the effects of BMI and head size were also studied and it was observed that both affected the AEP latencies and IPL differences independently. Head size is an established variable that independently affects the outcome of AEP [5,6]. Although the effect of these variables on AEP has been studied extensively outside India, there remains a paucity of data in the Indian context. Further, most studies have not included an important AEP feature, the waveform V/I amplitude ratio, which indicates the involvement of the auditory pathway in hearing loss, whether central or peripheral. In one such study, it was oberved that both IV–V/I and IV–V/III amplitude ratios were independent



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of sex, but the IV–V/I ratio increased significantly with age [7]. The effect of BMI and head size on the V/I ratio has not been studied so far. Against this background, the present study aims to assess BAEP features including the V/I ratio and to study the effects of BMI and head circumference on these features.

## Materials and methods

The present study was carried out in the Clinical Neurophysiology Laboratory at a medical teaching institute in central Gujarat during May–June 2013. The study was approved by the institutional human ethics committee (IHEC). Written informed consent was obtained in vernacular language structured format from all the participants and the study was carried out in accordance with the World Medical Association Declaration of Helsinki.

### Selection of participants

Participants were mostly young staff and students from the medical hospital and college. Thirty male participants in the age range 19–25 years were selected after a thorough clinical and otological examination for inclusion and exclusion criteria. Individuals prone to occupational or any other causes of hearing loss, with H/O hypertension, diabetes, hypothyroidism, musculoskeletal disorders, neuromuscular disorders, developmental disorders, facial asymmetry, ototoxic drugs intake, etc. were excluded from the study.

### Recording of BERA

All participants were subjected to BERA testing according to standard techniques on an RMS Portable Aleron EP-Electromyograph machine manufactured by RMS Recorders and Medicare System (Chandigarh, India). Recording of BERA was carried out in a quiet and dimly lit room with the participant in the supine position. Participants were briefly informed about the procedure. Restless, irritable, and apprehensive participants were allowed to relax for 5–10 min before testing. Surface electrodes were placed at the vertex (CZ), both ear lobes (Ai and Ac), and the forehead (ground). Monaural auditory stimulus consisting of rarefaction clicks of 100 $\mu s^2$ pulse were delivered through an electrically shielded earphone at a rate of 11.1/s. The contralateral ear was masked with pure white noise 30 dB below that of the BERA stimulus. A band pass of 10–3000 Hz was used to filter out undesirable frequencies in the surrounding. Responses to 2000 click presentations were live averaged to obtain a single BERA waveform pattern. Waveforms were obtained at 25, 40, 60, and 90 dB in each ear. Data of waveforms obtained at 90 dB were used for analysis. APL of waves I, III, V, IPL of I–III, III–V, I–V wave forms, and V/I ratio were considered for assessment. Figure 1 shows the BERA waveforms with different parameters recorded in a normal participant.

### Statistical analysis

The Graph Pad Prism statistical tool was used for analysis (GraphPad Software, Inc., California, USA). Range, reference limit, and mean ± SD for all BERA waveforms latencies and latency differences (ms) and V/I ratio (%) were obtained. Simple correlation regression (*r*) was performed to determine the effect of BMI and head circumference with different AEP features.

## Results

In the present cross-sectional study, 30 male participants age range 19–25 years, BMI range 15–26 kg/m$^2$, and head circumference range 50–58 cm underwent BAEP electodiagnostic study. Their mean and SD values are shown in Table 1.

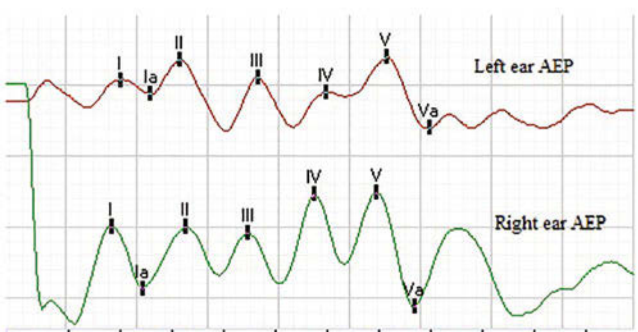
Table 2 shows different variables of BAEP, its range, reference limits, and mean values with SD. No side-to-side statistically significant difference was observed among any of the variables under study ($P > 0.05$).

Figure 2 shows the correlation of Vth wave latency with head circumference. Table 3 shows the correlation

**Table 1 Demographic and anthropometric profile of the study population**

| Parameters | Mean ± SD | Range |
|---|---|---|
| Age (years) | 22 ± 2.3 | 19–25 |
| BMI (kg/m$^2$) | 20.44 ± 2.51 | 15–26 |
| Head circumference (cm) | 55.4 ± 2.07 | 50–58 |

**Figure 1**




| Waves | I | II | III | IV | V | I-III | I-V | III-V | I-Ia | V-Va | A(R) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Left Ear | 1.77 | 2.6 | 3.71 | 4.67 | 5.52 | 1.94 | 3.75 | 1.81 | 0.1 | 0.5 | 4.83 |
| Right Ear | 1.65 | 2.69 | 3.56 | 4.5 | 5.38 | 1.92 | 3.73 | 1.81 | 0.44 | 0.8 | 1.84 |

BAEP waveforms in normal human participants on either side, with their latencies interpeak latency (IPL) differences and amplitudes ratios.

**Table 2 BAEP variables and their reference values/normative data of the study population**

| BERA waveform variables | Range (minimum–maximum) | | Reference limit | | Mean ± SD | |
|---|---|---|---|---|---|---|
| | Left | Right | Left | Right | Left | Right |
| I latency (ms) | 1.38–2 | 1.29–1.96 | 1.82 | 1.74 | 1.63 ± 0.19 | 1.58 ± 0.16 |
| III latency (ms) | 3.25–4.27 | 3.35–4.25 | 3.92 | 3.93 | 3.67 ± 0.25 | 3.69 ± 0.2 |
| V latency (ms) | 5.19–5.77 | 5.1–5.85 | 5.62 | 5.6 | 5.47 ± 0.15 | 5.49 ± 0.19 |
| I–III latency difference (ms) | 1.52–2.5 | 1.79–2.83 | 2.28 | 2.35 | 2.05 ± 0.23 | 2.11 ± 0.24 |
| I–V latency difference (ms) | 3.5–4.4 | 3.27–4.46 | 4.06 | 4.3 | 3.85 ± 0.21 | 3.95 ± 0.28 |
| III–V latency difference (ms) | 1.25–2.42 | 1.08–2.5 | 2.07 | 2.1 | 1.8 ± 0.2 | 1.84 ± 0.29 |
| V/I ratio | 0.13–17.9 | 0.05–6.27 | 0.31 | 0.23 | 0.98 ± 0.68 | 0.93 ± 0.7 |

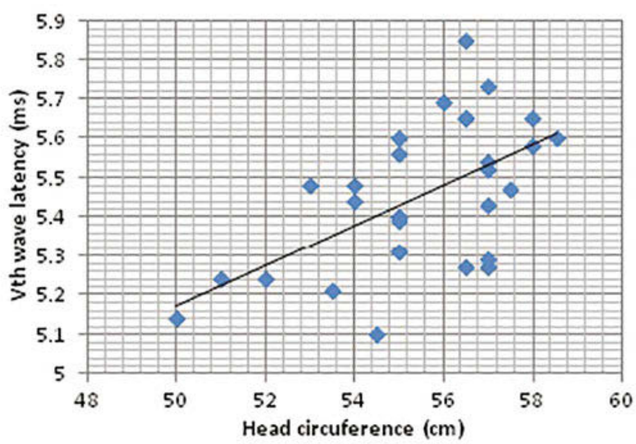
**Table 3 Correlation coefficients (*r*) for BERA variables with BMI and head circumference**

| AEP parameters | Correlation coefficient (*r*) | | | |
|---|---|---|---|---|
| | BMI | | Head circumference | |
| | Left | Right | Left | Right |
| APL-I | −0.05 | −0.05 | 0.039 | −0.15 |
| APL-III | −0.09 | −0.04 | 0.03 | 0.005 |
| APL-V | 0.03 | 0.22 | 0.18 | 0.57* |
| I–III IPL difference | −0.05 | −0.02 | 0.01 | 0.05 |
| I–V IPL difference | 0.09 | 0.18 | −0.04 | 0.38* |
| III–V IPL difference | 0.13 | −0.02 | 0.17 | 0.32* |
| V/I ratio | 0.07 | 0.08 | 0.08 | 0.148 |

AEP, auditory evoked potential; IPL, interpeak latency; *Significant positive correlation.

coefficient values of different parameters with BMI and head circumference. A significant positive correlation was observed between Vth wave latency and head circumference. No correlation was observed between different variables and BMI.

**Figure 2**




Correlation between BERA V wave latency and head circumference.

## Discussion

The present study observed the effect of head circumference and BMI on different parameters of AEP in young healthy male participants. As we had already excluded sex and age factors from the study, it clearly accounts for the effect of only these two variables on AEP. We observed that of seven AEP parameters under study, APL-V waveform, IPL difference I–V, and III–V showed a positive correlation with head circumference. V waveform latency showed a very strong correlation. The other IPL difference showed a weaker correlation with head size. There was no correlation between any of the AEP parameters and BMI.

A positive correlation between head size and AEP latencies, IPL differences reinforces the fact that head circumference reflects brain size, which affects the conduction time of the neural pathway, and hence should be considered an independent variable while interpreting AEP results [8,9]. It is well established that adult AEP IPL latency has a strong correlation with brain-stem size and a weaker correlation with head size [10]. In a study with a large clinical sample, head size and IPL I–V were found to be very poorly correlated and it was concluded that even IPL has no clinical relevance [11].

We also explored the V/A amplitude ratio, which is an essential measure for delineation of central and peripheral auditory pathway involvement. Normative values of the ratio obtained from the present cohort (0.98 ± 0.68 Lt ear and 0.93 ± 0.7 Rt ear) were different from those of previous studies by Gathe *et al.* [12] (2.03 ± 0.76 and 2.15 ± 0.81) and Thakur *et al.* [13] (3.3 ± 5.83 and 1.87 ± 0.95). Interstudy differences observed in the values may be attributed to variable cohort and sample sizes in different study populations from different geographical areas. Further, the present study found a lower and upper limit of normal of 0.3, 0.23 (Lt, Rt) and 1.66, 1.63 (Lt, Rt), respectively. The literature suggests that if the amplitude ratio is below 0.5, it may be consistent with central impairment and if it is above 3.0, it may be consistent with peripheral auditory pathway impairment [14]. Thus, with wide differences in the normative values obtained in each study and its importance in delineating the central versus the peripheral auditory pathway, further research in this domain with a large sample size is essential.

BMI-related observations in AEP are in accordance with a previous study by Solanki *et al.* [6]. In a comparison study of AEP parameters between obese participants (>30 BMI) and controls (<30 BMI) among healthy young adults, significant differences were observed [15]. These findings were not corroborative with observations in present study. Both studies have limitations of smaller sample size and hence results can not be extrapolated to generalized population. Hence further studies with larger sample size are required to explore association of BMI with AEP parameters. Although, association of BMI with peripheral neuropathies have been well established but it's association with cranial neuropathies remains unanswered.

## Conclusion

The small sample size and the small BMI range remain the major limitations of this study. It can be concluded that head size remains an independent variable affecting AEP parameters. Although the V/I amplitude ratios were within the normal range, a study with a larger sample size should be carried out for better interpretation.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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