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RESEARCH ARTICLE

Anthropometric differences and gender variations in brainstem auditory evoked responses - A cross-sectional study in North Indian population

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ABSTRACT

Background: Gender is a known physiological variable reported to have influences on brainstem auditory evoked potential (BAEP) latencies irrespective of age. Anatomical differences have been suggested for such variations. **Aims and Objectives:** The present study was, hence, undertaken to evaluate the influence of gender on BAEP latencies and to assess the role of head size and body mass index (BMI) on BAEP responses and in gender variations. **Materials and Methods:** BAEP was recorded in 100 healthy adults (50 males and 50 females) in the age group of 18-70 years. Comparisons of absolute and interpeak latencies (IPLs) in the genders and between the groups with different head sizes and BMI were performed by unpaired *t*-test. Correlations between head size and BMI with BAEP latencies were obtained by Pearson correlation coefficient. $P < 0.05$ was considered as significant statistically. **Results:** A statistically significant increase in BAEP absolute latencies I, III, and V and IPLs I-III and I-V was found in males as compared to females. A significant positive correlation of head size was obtained with absolute latency I, III, V and I-V IPL. $P < 0.05$ for comparison of groups with different head sizes for absolute latencies I, III, V, I-V IPL and that with different BMI for I, III, V and I-III and I-V IPLs. Gender differences turned non-significant ($P > 0.05$) in males and females of comparable head sizes. **Conclusion:** Gender has significant influence on BAEP latencies. Head size and BMI are independent physical variables affecting BAEP latencies with the former having important role in gender differences.

KEY WORDS: Brainstem Auditory Evoked Potentials; Absolute Latency; Interpeak Latency; Gender Variations; Head Size

INTRODUCTION

Brainstem auditory evoked potentials (BAEPs) are the electrical potentials recorded from the scalp by stimulation of the auditory pathways. BAEPs may provide valuable information regarding brainstem integrity. Since their introduction to clinical medicine in the 1970s, they possess well-established utility in neurology, neurosurgery, anesthesiology, neonatology, and audiology.[1,2] There are five main BAEP waveforms which represent the electrical activity in auditory pathways between the cochlea and the brainstem. Clinically, the most important waves are the waves I, III, and V.[3] The parameters of BAEP, especially wave latencies have a normal variability due to various non-pathologic factors including stimulus and recording parameters as well as individual parameters such as age, gender, head size, and body mass index (BMI). Technical parameters can be standardized for each laboratory but individual's factors or interindividual variability still can have influences on the normal data limiting the clinical value of the test. Normal values have to be adjusted for various confounding physiological factors. Age and gender are known to have considerable influence

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on BAEP parameters and have been studied extensively in various parts of the country. Among the two, gender has been reported to influence the BAEP responses irrespective of the age and has more powerful effects on BAEP parameters than aging.[4-6] Influence of gender has also been demonstrated in various studies which have included selective age groups, for example, children and young adults or older individuals.[7,8] Gender, hence, seems to vary BAEP records considerably. Head size constitute another important physical variable as it indirectly reflects the brain size and the length of the visual pathway and hence the conduction time. It can prove to be an important source of interindividual variability. Moreover, head size has been speculated by many authors as a factor accounting for gender differences in BAEP latencies.[9-14] However, there are conflicting results as there are some authors who have not found the latency differences with the head sizes and have suggested the role of hormonal influences for gender differences in BAEP latencies as the source of the gender variability.[15,16]

Apart from the head size differences, other anatomical differences such as variations in height and weight are common findings in gender-based study groups. It can be reflected in BMI which is another important physiological parameter and a known source of physiological variations. Gender variability in BAEP responses has been attributed to such anatomical differences (head size and body size). However, paucity of substantial evidence still exists.[15,16] Hence, the present study was planned to estimate the influence of gender on BAEP responses in healthy individuals with normal hearing with a wide age range. The study also aimed at assessing the role of differences in head sizes and BMI on BAEP responses and as the basis of differences in BAEP records among the gender.

MATERIALS AND METHODS

It was a cross-sectional analytical study conducted on 100 healthy adults in the age group of 18-70 years (50 males and 50 females) from Mullana, Ambala (Haryana). The test was performed in Neurophysiology laboratory in the Department of Physiology, Maharishi Markandeshwar Institute of Medical Sciences and Research, Mullana, Ambala. Approval from the Institutional Ethical Committee was taken to carry out the research work. A complete neuro-otological examination of each individual was done after obtaining a written informed consent and a detailed clinical history. The height (in cm) and weight (in kg) of the individual were measured as a part of the general examination. BMI was calculated as weight (kg)/height (mts^2). Head size was measured (from nasion to inion) by a measuring tape before BAEP recording.

Inclusion Criteria

Adult healthy individuals in the age group of 18-70 years with normal neuro-otological examination.

Exclusion Criteria

Individuals with external/middle/inner ear pathology, systemic diseases such as diabetes mellitus and hypertension, HIV infection, hereditary and degenerative diseases, chronic use of ototoxic drugs, previous history of head trauma, tobacco-chewing, chronic alcoholism or cigarette smoking, ear surgery, and radiotherapy or chemotherapy.

BAEP Recording

BAEP was performed on Allengers Scorpio-electromyography (EMG), evoked potentials (EP), nerve conduction study (NCS), in neurophysiology laboratory made sound and light attenuated for the test. Individuals were informed about the procedure and apprehensive and restless individuals were allowed to relax before starting the procedure. Methodology for the test employed was standardized as recommended by guidelines on short latency auditory evoked potentials by American Clinical Neurophysiology society.[17] Preparation of scalp skin was done before the electrode application. 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.[17] Monaural auditory stimulus with rarefaction clicks (0.1 ms pulse) and 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 responses were recorded and superimposed to ensure the reproducibility of the waveform.

Parameters for the study were absolute latencies of wave I, III, and V and interpeak latencies (IPLs) I-III, III-V and I-V. The data were expressed as mean ± standard deviation (SD). The significance of differences in head sizes and BMI between males and females and those in absolute and IPLs between males and females were obtained by unpaired t test. Correlations between the head sizes and BAEP latencies and BMI and BAEP latencies were obtained by Pearson correlation coefficient (r). Head sizes and BMI influences were also studied by dividing the individuals (mean age of the total individuals: 25 ± 2.6 years) into two groups based on their head sizes as: Group 1 (head size: 31-33 cm) and Group 2 (head size: 34-36 cm), as well as based on their BMI as: Group 1 with normal BMI (BMI: 18.5-24.9) and Group 2 with high BMI (BMI >25) and the significance of the difference in absolute and IPLs between the groups were analysed by unpaired *t*-test. Absolute and IPLs were also compared between males and females of comparable age and head sizes. Statistical analysis was done using SPSS (Statistical package for social science) version 20.0 statistical software at 5% level of significance.

RESULTS

The study comprised of 100 healthy adults (50 males and 50 females) in the age group of 18-70 years. A gender comparison of anthropometric parameters revealed significant differences ($P < 0.001$) in height, weight and head size of the individuals (Figure 1). BMI comparison, however, did not reveal statistically significant differences ($P > 0.05$).

BAEP absolute and IPL comparison between males and females revealed statistically significant differences ($P < 0.05$) for absolute latencies I, III, and V and also for IPLs I-III and I-V (both ears) (unpaired *t*-test) (Table 1).

Significant positive correlations of head size and absolute latency I, III, and V and that with IPL I-V were obtained (by Pearson correlation coefficient). This correlation was significant when studied in males and females separately and also in the total individuals (Table 2).

The effect of head sizes on BAEP latencies was further studied by classifying the individuals (mean age: 25 ± 2.6 years) into two groups with different head sizes (Group 1 with head size 31-33 cm and Group 2 with head size of 34-36 cm) and analyzing the absolute and IPL differences between the groups. Absolute latencies (I, III, and V) were found to be longer in Group 2 as compared in Group 1 with statistically significant differences (unpaired *t*-test). However, no such variations could be found for IPLs (except IPL I-V) between the two groups (Table 3). Similarly, the comparison between the groups with normal and high BMI (Group 1 with BMI: 18.5-24.9 and Group 2 with BMI >25) revealed statistically significant increase in absolute latencies I, III, and V and I-III and I-V IPLs in Group 2 as compared to Group 1 by unpaired *t*-test (Table 3).

Absolute latencies were further compared between males and females (of comparable age) with comparable head sizes. The differences did not exhibit statistical significance ($P > 0.05$) between the gender then (Table 4).

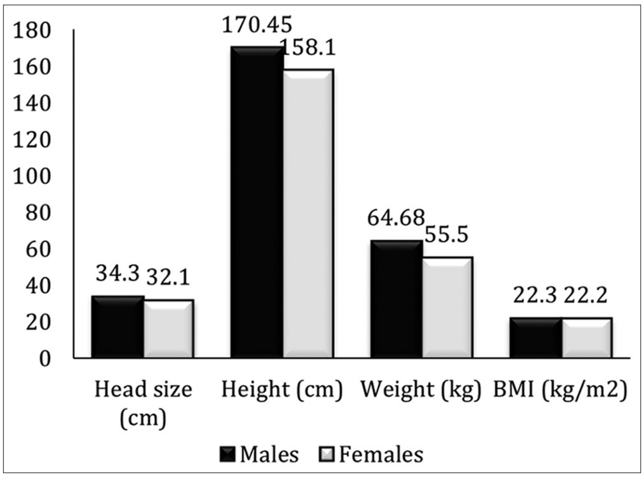

Figure 1: Anthropometric data compared in males and females

Table 1: Gender comparisons of mean absolute and interpeak BAEP latencies

Gender	Mean absolute latency wave I (ms±SD)*		Mean absolute latency wave III (ms±SD)*		Mean absolute latency wave V (ms±SD)*		Mean IPL wave I-III (ms±SD)*		Mean IPL wave III-V (ms±SD)		Mean IPL wave I-V (ms±SD)*	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Male *n*=50 (mean HS: 34.3±0.92 and mean BMI: 22.3±2.38)	1.72±0.11	1.71±0.12	3.79±0.13	3.78±0.15	5.79±0.12	5.78±0.11	2.07±0.06	2.07±0.07	2.0±0.06	2.0±0.07	4.07±0.04	4.07±0.05
Female *n*=50 (mean HS: 32.1±1.05 and mean BMI: 22.2±3.22)	1.66±0.08	1.658±0.09	3.687±0.14	3.67±0.13	5.66±0.11	5.67±0.12	2.02±0.08	2.02±0.1	2.02±0.06	2.0±0.0	4.0±0.05	4.02±0.04
P value	<0.0001	<0.001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.019	>0.05 NS	<0.0001	<0.0001

n: Number of subjects, HS: Head size, BMI: Body mass index, NS: Not significant, *$P<0.0001$ (unpaired *t*-test) for the increase in absolute latencies I, III and V and IPLs I-III and I-V between males and females (in both right and left ears), ($P<0.05$ [unpaired *t*-test] for the differences in head sizes between males and females while $P>0.05$ for BMI differences between males and females). IPLs: Interpeak latencies, SD: Standard deviation, BAEP: Brainstem auditory evoked potential

Table 2: Correlation coefficients (r) between head sizes and absolute and interpeak BAEP latencies

Gender	Correlation coefficients (r)											
	Wave I*		Wave III*		Wave V*		I-III		III-V		I-V*	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Male (*n*=50)	0.305	0.314	0.3	0.29	0.32	0.29	0.15	0.18	0.13	0.02	0.38	0.34
P value	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	<0.01	<0.05
Female (*n*=50)	0.515	0.448	0.488	0.501	0.54	0.518	0.2	0.22	−0.22	−0.21	0.58	0.52
P value	<0.001	<0.01	<0.001	<0.001	<0.0001	<0.001	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	<0.0001	<0.001
Total (*n*=100)	0.475	0.45	0.39	0.373	0.39	0.389	0.18	0.19	−0.12	−0.13	0.36	0.26
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	<0.001	<0.01

n: Number of subjects, NS: Not significant, *$P<0.05$ for significant positive correlation (Pearson correlation coefficient) between head size and absolute latency I, III and V and IPL I-V. BAEP: Brainstem auditory evoked potential, IPLs: Interpeak latencies

BMI and BAEP latencies exhibited significant positive correlation with absolute latencies I, III, and V, in females studied separately and also in total individuals. No significant positive correlation of BMI with absolute latencies could be obtained in males. In addition, no significant positive correlation of BMI with IPLs could be obtained except that with I-III IPL studied in total individuals (Table 5).

DISCUSSION

Clinical utilities of all the tests, particularly neurophysiological investigations largely depend on the acquisition of carefully collected and skilfully analyzed normative data. Gender is a known physiological variable reported to influence the normal BAEP responses and anatomical differences have been suggested for such variations in BAEP parameters, particularly for BAEP latency differences. The present study has evaluated the influence of gender on BAEP latencies (absolute and IPLs) and an attempt has been made to assess the role of anthropometric measures such as head size and BMI on BAEP responses as well as in gender variations.

The present study demonstrated a significant head size (mean ± SD) variation in male (34.3 ± 0.92) and female (32.1 ± 1.05) individuals (Figure 1 and Table 1). Absolute latencies of wave I, III, and V and IPLs I-III and I-V were found to be longer in males with statistical significance as compared to females (Table 1). Many studies in the past report latency prolongation in males as compared to females.[4,10,15,18-23]

The most common latency prolongation in previous similar studies was that for absolute latencies III, V, and IPLs I-III and I-V in various studies (Aoyagi et al., Soares do et al. and Harinder et al.).[11,18,19] Rosenhall et al. reported the same in III, V, and I-V IPL.[20] These latency differences have been explained by different authors on the basis of the anatomical differences, most importantly differences in the head sizes of males and females.[9-11,13,14,23] However, there are some studies which do not consider head size as exclusive contributor in latency prolongation.[15,16]

In addition, a significant positive correlation of head size and all the three absolute latencies tested (I, III, and V) and IPL I-V was evident when studied in males and females separately and in the total study group as well, which comply with other similar studies (Table 2).[9,11,17,25] Among these studies, Dempsey et al. obtained a positive correlation with wave V and I-V IPL.[9] Aoyagi et al. stated the same with absolute latency III, V, I-III, and I-V.[11] Fukaya and Hosoya reported positive correlations between the head size and absolute latencies of wave III, V and the I-V IPL.[24] In yet another study by Ghugare et al., head size was found to be significantly correlated with wave V and interpeak I-V and III-V.[25]

The influence of the head size on BAEP latencies was further reinforced in the present study by the findings obtained after comparison between the two groups with different head sizes (Table 3). Furthermore, the gender differences in absolute BAEP latencies obtained in our study were studied again in males and females with comparable head sizes and the differences were then found to turn non-significant statistically (Table 5). The findings comply with a previous study which reported reduced magnitude of difference in BAEP latencies in males and females of comparable head sizes.[12] Still some studies suggest functional anatomic correlation to be too weak to be considered as a valid explanation for latency differences between the genders.[16,26] One such study examined the effects of hormones, head size, and oral temperature on BAEP parameters and found that head size affected waves III and V absolute latency but concluded that it is not entirely responsible for latency differences and gender difference is a combination of hormonal and head size differences.[27]

Regarding the appropriateness of various head size parameters for predicting the length of the auditory pathway, Trune et al. emphasized that more precise brain distances could be obtained by intracranial measures with imaging techniques for a precise relationship between brain size and BAEP latencies.[15]

Table 3: Comparison of mean absolute and IPLs in groups (mean age: 25±2.3 years) with different head sizes and BMI

Head size	Mean absolute latency wave I		Mean absolute latency wave III		Mean absolute latency wave V		Mean IPL I-III		Mean IPL III-V		Mean IPL I-V	
	R	L	R	L	R	L	R	L	R	L	R	L
Group 1 (head size: 31-33 cm) (*n*=22)	1.59±0.04	1.59±0.039	3.59±0.11	3.58±0.11	5.61±0.06	5.62±0.07	1.98±0.09	1.98±0.08	2.03±0.08	2.05±0.05	4.0±0.06	4.02±0.04
Group 2 (head size: 34-36 cm) (*n*=22)	1.64±0.04	1.64±0.03	3.65±0.04	3.64±0.03	5.65±0.06	5.67±0.04	2.0±0.05	1.99±0.04	2.0±0.03	2.02±0.03	4.06±0.04	4.04±0.04
P value	<0.01	<0.001	<0.05	<0.05	<0.05	<0.05	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	<0.001	<0.05
Group 1 (BMI: 18.5-24.9) (*n*=22)	1.59±0.06	1.59±0.05	3.58±0.07	3.59±0.06	5.59±0.09	5.59±0.08	1.99±0.03	1.98±0.02	2.01±0.04	2.01±0.05	4.01±0.04	4.0±0.05
Group 2 (BMI: >25) (*n*=22)	1.65±0.06	1.64±0.07	3.71±0.13	3.7±0.14	5.69±0.09	5.7±0.09	2.06±0.09	2.06±0.1	1.99±0.06	1.99±0.08	4.04±0.05	4.05±0.06
P value	<0.05	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	0.16 NS	0.49 NS	0.01	0.01

n: number of subjects, R: Right ear, L: Left ear, NS: Not significant, $P<0.05$ for absolute latencies I, III and V and IPL I-V compared between the groups with different head sizes, $P<0.05$ for absolute latencies I, III and V and IPLs I-III and I-V between the groups with normal and high BMI (by unpaired *t*-test). BMI: Body mass index, IPLs: Interpeak latencies

Gender difference, in the present study also exhibited a significant prolongation of wave I absolute latency. The finding has also been reported by some studies in the past.[4,22] Wave I is the representation of CNAP (compound nerve action potential) in the distal portion of VIII nerve. The response is believed to originate from nerve fibers as they leave the cochlea and enter the internal auditory meatus. Wave I absolute latency prolongation in our study can be explained on the basis of the documented differences in male and female peripheral hearing mechanism. Males and females differ in cochlear size with males having longer cochlear ducts than females resulting in longer cochlear travel times in males.[28,29]

Correlation of BMI with BAEP latencies revealed positive correlations of absolute latencies I, III, and V in females, studied separately and in the total study group but could not be obtained for the male individuals (Table 5). Among IPLs only I-III IPL exhibited a positive correlation with BMI in total individuals and not in males and females studied separately. It could be explained on the basis of a smaller sample size than that required for a correlation study (<80). Similar studies involving such correlation of BMI with the BAEP latencies are very few. Moreover, they do not report significant influence of BMI on BAEP latencies.[12,25]

The influence of BMI, when studied by a comparison performed between the two groups with normal and high BMI revealed significantly increased absolute latencies I, III, and V and IPLs I-III and I-V in the group with high BMI (Table 3). In a previous similar comparison study for BAEP latencies between obese (>30 BMI) and normal (<30 BMI) young adults, significant differences were observed for waves I, III, and V with no significant change in the inter peak latencies I-III, III-V, and I-V.[30] In the present study, BMI seems to affect the BAEP latencies but regarding role of the same in gender variations, it was found that mean BMI in males (22.3 ± 2.38) was not significantly different from that in females but still males exhibited increased latencies than females (22.2 ± 3.22). This fact attenuates the possibility of the role of BMI in gender variations found in BAEP absolute latencies (Figure 1 and Table 1). The study, on the other hand, has found stronger evidences in support of the role of head size differences for influencing the BAEP latencies independently and also as the important basis of differences in the BAEP records among the gender.

Limitation

The role of hormones in the gender variations in BAEP records could have been evaluated as well, in the present study, which could have contributed in elaborating the basis of the differences in the BAEP values among males and females.

Table 4: Mean absolute BAEP latencies compared in males and females with comparable age and head sizes

Gender	Mean age (years±SD)	Mean head size (cm±SD)	Mean absolute latency wave I (ms±SD)		Mean absolute latency wave III (ms±SD)		Mean absolute latency wave V (ms±SD)	
			Right ear	Left ear	Right ear	Left ear	Right ear	Left ear
Males (*n*=20)	31.69±7.0	33.34±0.49	1.63±0.05	1.62±0.05	3.65±0.08	3.64±0.07	5.65±0.08	5.66±0.08
Females (*n*=20)	32.69±6.31	32.7±0.597	1.61±0.03	1.62±0.02	3.66±0.04	3.67±0.05	5.68±0.04	5.67±0.04
P value			>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS

n: Number of subjects, NS: Not significant, *P*>0.05 for absolute latency differences between males and females with comparable head sizes. SD: Standard deviation, BAEP: Brainstem auditory evoked potential

Table 5: Correlation coefficients (r) between BMI and absolute and interpeak BAEP latencies

Gender	Correlation coefficients (r)											
	Wave I		Wave III		Wave V		I-III		III-V		I-V	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
Males (*n*=50)	0.178	0.169	0.173	0.211	0.181	0.164	0.072	0.136	−0.004	−0.18	0.099	0.062
P value	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS
Females (*n*=50)	0.37	0.33	0.36	0.35	0.34	0.22	0.21	0.2	−0.22	−0.2	0.2	0.14
P value	<0.01*	<0.05*	<0.05*	<0.05*	<0.05*	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS
Total (*n*=100)	0.20	0.24	0.21	0.22	0.29	0.2	0.26	0.2	−0.13	−0.17	0.15	0.109
P value	<0.05*	<0.05*	<0.05*	<0.05*	<0.01*	<0.05*	<0.01*	<0.05*	>0.05 NS	>0.05 NS	>0.05 NS	>0.05 NS

n: Number of subjects, NS: Not significant. **P*<0.05, for positive correlation of BMI with absolute latencies I, III and V in females and total subjects (not in males) while for IPLs, *P*<0.05, for positive correlation of BMI with only I-III IPL among total subjects (no significant positive correlation in males and females studied separately). BAEP: Brainstem auditory evoked potential, BMI: Body mass index, IPLs: Interpeak latencies

CONCLUSION

Gender is an important variable influencing BAEP latencies with prolonged latencies in males. In addition, anthropometric measure such as head size and BMI should be taken into account besides age and gender in the acquisition of a normative BAEP data to optimize the clinical value of the test. Head size can also be considered as one of the important factors in gender differences in BAEP latencies as it accounts for differences in relative distance of anatomical generators of BAEP waves. Further studies with more precise measurement of the brain size could contribute to establish this relationship in a stronger manner. In addition, the extent of the role of hormones needs to be evaluated in gender variability of BAEP responses.

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