

# Impact of Tinnitus Masking on Auditory Brainstem Response Results

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## ABSTRACT

**Introduction:** Tinnitus- the perception of sound without external stimulation can also lead to disruption in the quality of life and has been over the years been benefitted by tinnitus masking. Hence this study to understand the effectiveness of tinnitus masking using the Auditory Brainstem Response (ABR) Test.

**Objectives:** The intention of this experimental research design is to determine whether tinnitus masking as treatment for tinnitus makes a significant difference in auditory evoked brainstem responses before and after masking for understanding the effectiveness of the treatment objectively and possible quantification of benefit measurement through ABR.

**Design:** 30 subjects with normal hearing and unilateral tinnitus were assessed using ABR before and after tinnitus masking. Data was collected and compared to evaluate pre-masking and post-masking values of Latency-Intensity function and Interpeak Latency differences. Data was analyzed using descriptive statistics, test of homogeneity of variances and Two-way ANOVA.

**Results:** Both latency-intensity functions and interpeak latency differences showed significant differences before and after tinnitus masking with significance values of Two-way ANOVA as .001, (Calculated at  $p < .05$ ).

**Conclusions:** Despite the patient's subjective feedback, objective proof of the patient's benefit is a necessity. Therefore, this study shows that ABR shows significant differences in patients treated with tinnitus masking. Further suggesting benefit quantification of tinnitus masking as a treatment to tinnitus suffering individuals and for further understanding the intricacies of changes in the central auditory pathway due to masking.

**Keywords:** Tinnitus masking; Latency-Intensity Functions; Interpeak Latency differences; objective measurement of benefit.

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## INTRODUCTION

Tinnitus is the perception of a sound that results exclusively from activity within the nervous system without any corresponding mechanical, vibratory activity within the cochlea, and unrelated to external stimulation<sup>1</sup>. Early-response auditory evoked potentials (AEPs) in humans are significantly altered in tinnitus. These changes are closely related to that seen in animals, leading to new approaches to study tinnitus based on objective parameters<sup>2</sup>. The benefits of tinnitus masking in treatment of tinnitus has been long defined<sup>3-5</sup>. Yet, information on literature regarding the Latency Intensity (LI) Functions and Interpeak Latency Differences of ABR in relation to tinnitus and tinnitus treatment benefits as an objective assessment tool is very limited. None of the objective measures of tinnitus source, severity and therapeutic or management effect were available objectively. Thus, ABR may serve this purpose of an objective indicator for audiological profile of tinnitus<sup>6-7</sup>. Hence, the intention of this study is to compare the pre and post masking Latency-Intensity Functions and Interpeak Latency differences measured by ABR among normal hearing participants with unilateral tinnitus before and after tinnitus masking electro physiologically examining the efficacy of tinnitus masking in the presence of perceptual benefit using Tinnitus Handicap Inventory (THI).

## MATERIALS AND METHODS

Participants suffering from unilateral tinnitus having subjective, permanent, stable, and spontaneous (not occurring only during exposure to noise or immediately after) tinnitus were included in this study. Only those patients were included who did not report any history of diseases involving middle ear, cardiovascular and neurologic origin; Meniere's disease and diabetes. Those undergoing ototoxic medications (since at least last 6 months) were excluded<sup>8</sup>.

**Procedure:** After a detailed physical examination that included a complete otorhinolaryngologic examination, a general investigation was carried out which consisted of use of a conventional calibrated<sup>9</sup> diagnostic audiometer named MAICO MA53 with TDH 3<sup>9</sup> earphones, and a calibrated<sup>10</sup> immittance audiometer (GSI-39 AUTO TYMP) were used in all the cases to confirm normal hearing sensitivity. Not more than 25-dB hearing level<sup>11</sup> at each frequency in the conventional audiometric range between 250 Hz to 8 kHz by using Modified Hughson-Westlake technique<sup>12</sup>. All the participants considered showed 'A' type tympanograms. The ABR recordings were obtained using calibrated (according to manufacturer's standards) Nicolet Viking Quest<sup>TM</sup> Version<sup>12</sup> (Nicolet Viasy) equipment and insert earphones (Nicolet, MADISON

WI537<sup>11</sup>, and Model: TIP-300). After cleaning the surface of the skin, the conductive electrode paste (Ten20 Conductive Neurodiagnostic Electrode Paste; Weaver and Company) was placed on the skin and on the electrodes. Patients were asked to stay quiet and relaxed in order to avoid artifacts related to muscle responses and they usually placed in a reclining position with good support to the neck and are often encouraged to close their eyes and sleep during the recording process. The test room should be quiet enough to meet the current ANSI standards for background noise<sup>13</sup>. Electrical shielding of the environment is another consideration that may reduce interference of electrical artifacts in the ability to obtain clear, readable recording. The electrodes should be securely attached with tape. Impedance values were below 5000 ohms for all electrodes and in all the cases. After electrode placement and impedance checking, total 2000 rarefaction clicks were delivered starting from 80-dB hearing level<sup>7,14</sup>; to threshold level (where Peak or Wave V was prominently detected) of the participants for each intensity at a repetition rate of 11.1 clicks per second through the insert earphones with a Pulse duration 0.1 milliseconds with rise time Less than 0.5 milliseconds (Table 1).

**Data Collection:** Self-administrable questionnaire THI<sup>15</sup> was provided to be filled before and after tinnitus masking to understand their perceptual benefit: 0-16: Slight or no handicap (Grade 1); 18-36: Mild handicap (Grade 2)38-56: Moderate handicap (Grade 3)58-76: Severe handicap (Grade 4); 78-100: Catastrophic handicap (Grade 5)<sup>16</sup> and performed ABR in all patients before tinnitus masking. After 60 sessions of tinnitus masking using the MAICO MA53 audiometer using the TDH-39 circumaural earphone, those with a change in THI score who shifted to a better grade, were then considered for post tinnitus masking ABR.

**Statistical Analysis:** To investigate the objectives of the present study, statistical analysis using Statistical Package for the Social Sciences (SPSS) software (version 16.0) was carried out for the obtained data. Measurements were calculated using Descriptive Statistics, Test of Homogeneity of Variances and the two-way Analysis of Variance (ANOVA) test.

## RESULTS

ABRs reflect activity in only one of multiple pathways from cochlear nucleus to midbrain. Latency-Intensity Functions and Interpeak Latency Differences measured by ABR help to determine the probable site of lesion of tinnitus. In this case, using these two parameters for the objective measurement of tinnitus masking benefit by comparing ABR responses before and after tinnitus

**Table 1:** Pre and post masking THI values.

THI Score	N	Mean	Std. Deviation	Std. Error Mean
Pre masking THI	30	62.00	8.50	5.223
Post masking THI	30	30.00	6.52	4.421

masking. The descriptive statistics was performed to calculate Mean, Standard Deviation, standard error, lower and upper bound (95% Confidence Interval of Mean), and minimum and maximum range to evaluate and compare the data. The two-way Analysis of Variance (ANOVA) test was incorporated to evaluate and compare the significant differences among normal hearing participants with unilateral tinnitus before and after tinnitus masking. In addition, test of Homogeneity of Variances was incorporated to check the presence or absence of homogeneity (based on significance values)

of the data among normal hearing participants with unilateral tinnitus before and after tinnitus masking and p value was considered as statistically significant when  $p < .05$  (Table 2). To prove the first hypothesis, that is, the significant differences in Latency- Intensity (LI) Functions measured by ABR among normal hearing participants with unilateral tinnitus before and after tinnitus masking, we made the following statistical analysis. To prove the second hypothesis stating that there will be significant differences in ABR Interpeak Latency Differences among normal hearing participants with unilateral tinnitus before

**Table 2:** Analysis of Latency-Intensity (LI) functions for normal hearing participants with unilateral tinnitus before and after tinnitus masking from ABR of tinnitus ear.

Latency-Intensity (LI) function of tinnitus ear	A <sub>1</sub>	Mean	Standard Deviation	Standard Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Pre-masking	450	3.7198	1.60130	.07549	3.5714	3.8681	1.45	5.95
Post-masking	450	3.1616	1.39329	.06568	3.0325	3.2906	1.20	4.95
Total for tinnitus ear pre and post masking	900	3.4407	1.52584	.05086	3.3408	3.5405	1.20	5.95
<b>Between component variance of LI function of affected ear before and after tinnitus masking</b>								0.15080
TEST OF HOMOGENEITY OF VARIANCES :								
Latency-Intensity (LI) function of tinnitus ear	Levene statistic	Degree of freedom (df1)	Degree of freedom (df2)			Significance	(calculated at $p < .05$ )	
	14.360	1	898			.001		
Two-Way Analysis of Variance (Two-Way ANOVA)								
Latency-Intensity (LI) function of tinnitus ear	Between Groups	Sum of Squares	Degrees of Freedom (df)	Mean Square	F Test	Significance	(Calculated at $p < .05$ )	
		70.113	1	70.113	31.124	.001		
	Within Groups	2022.934	898	2.253				
	Total	2093.047	899					

**Table 3:** Analysis of Interpeak Latency Differences for normal hearing participants with unilateral tinnitus before and after tinnitus masking from ABR of tinnitus ear.

Interpeak latency differences in Tinnitus Ear	A <sub>1</sub>	Mean	Standard Deviation	Standard Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Pre-masking	450	2.5543	1.04029	.04904	2.4580	2.6507	1.10	4.25
Post-masking	450	2.2286	.90862	.04283	2.1444	3.3127	1.05	3.55
Total for tinnitus ear pre and post masking	900	2.3914	.98965	.03299	2.3267	2.4562	1.05	4.25
<b>Between component variance of interpeak latency differences of tinnitus ear before and after tinnitus masking:</b>								0.5095
TEST OF HOMOGENEITY OF VARIANCES :								
Interpeak latency differences in Tinnitus Ear	Levene statistic	Degree of freedom (df1)	Degree of freedom (df2)			Significance	(calculated at $p < .05$ )	
	12.564	1	898			.001		
Two-Way Analysis of Variance (Two-Way ANOVA)								
Interpeak latency differences in Tinnitus Ear	Between Groups	Sum of Squares	Degrees of Freedom (df)	Mean Square	F Test	Significance	(Calculated at $p < .05$ )	
		23.880	1	23.880	25.304	.001		
	Within Groups	856.600	898	.954				
	Total	880.479	899					

and after tinnitus masking, we performed the following required statistical analysis. Statistical analysis Two-way ANOVA showed both Latency Intensity functions and Interpeak Latency Differences value as .001, hence statistically significant. Implying, indication of significant change in ABR post tinnitus masking using BBN (Table 3).

## DISCUSSION

ABR is the cost effective electrophysiological tool to explain predominant functions of neural activities contributing tinnitus<sup>17</sup>. Our parameters were such, because, tinnitus masking provides better short term effect<sup>17</sup> and BBN provides better adaptation than nature sounds<sup>18</sup>. Tinnitus masking was provided using Broad Band Noise at MML (Minimal Masking Level) + 20 dB for 30 mins twice in a day with a gap of 2 hours, a total of 60 sessions for all patients. Contralateral masking was not used because of insert earphones. Contralateral masking with Broadband noise doesn't affect the latency or amplitude of the ABR<sup>19</sup>. THI is a tinnitus-specific, widespread, and validated questionnaire for quantifying tinnitus severity in patient's daily lives<sup>15</sup>, and hence was used a perceptual benefit criteria for the study. Another study, also showed the occurrence of waves I and III in ABR in unilateral idiopathic subjective tinnitus with negative residual inhibition increased after masking<sup>20</sup>. Differences among normal hearing participants with tinnitus before and after tinnitus masking. With this outcome, we derive that presence of significant change in ABR parameters post tinnitus masking providing an insight to the requirement of further investigation. From quantification of the benefits of tinnitus treatments to the future aspects of ABR being a part of protocol of objective measurements of benefit of tinnitus masking to further open our understanding of how tinnitus masking or other tinnitus treatments are providing relief and to what extent. There is accumulating evidence from behavioral, neurophysiological, and neuroimaging studies that the acquisition of motor skills involves both perceptual and motor learning.<sup>21</sup> Motor learning, which is dependent on the plasticity of the brain, affects not only motor areas of the brain but changes sensory function as well. After even periods of training perceptual change has been found to have persisted for at least twenty four hours<sup>22</sup>. Re-training with tinnitus masking not only causes perceptual change but changes in brain plasticity due to motor learning caused by perceptual changes associated with sensorimotor adaptation. To be further studied with the help of radiological investigations.

## CONCLUSION

Pre- and post-therapeutic changes of normal hearing participants with tinnitus are easily measured by Latency Intensity Functions and Interpeak Latency Differences of ABR. Significantly delayed ABR peak or wave I, III and V were found in this study for the normal hearing participants with unilateral tinnitus before tinnitus masking than after. Therefore, significant differences of Latency Intensity

functions and Interpeak Latency Differences were found to be present among normal hearing participants with unilateral tinnitus before and after tinnitus masking. Concluding a possibility of using of Auditory Brainstem Response as a more cost effective objective assessment of benefit of tinnitus masking and other treatment protocols of tinnitus than other electrophysiological tests.

## CONFLICT OF INTEREST

The authors declare no potential conflict of interest

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