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The Association of Blood Type Differences and Signal-noise Ratio in TEOAE and DPAOE in Individuals with Normal Hearing

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ABSTRACT

Objective: The aim of this study was to investigate whether ABO and Rhesus (Rh) blood type systems are associated with distortion product otoacoustic emission (DPOAE) and transient otoacoustic emission (TEOAE) amplitudes, with the hypothesis that blood types affect hearing thresholds.

Methods: Seventy participants with normal hearing, aged 18-26 years, with normal tympanometry and otoscopic examination findings, were included in the study. TEOAE and DPOAE tests were conducted on all participants.

Results: The Rh factor did not significantly affect the OAE results. It was found that the TEOAE amplitudes of blood type B at 1.4 kHz in the left ear were higher than those of blood types A and AB. The amplitude of AB blood was lower than that of O, A, and B blood types at 2 kHz.

Conclusion: Our study results did not indicate a consistent pattern for a specific blood type, in contrast to previous findings. Additional research is required to investigate the potential correlation between hearing function and ABO and Rh blood types.

Keywords: Otoacoustic emissions, distortion product otoacoustic emissions, transient evoked otoacoustic emissions, blood type, signal to noise ratio, normal hearing

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INTRODUCTION

Blood is a body-specific fluid consisting of plasma, red blood cells, white blood cells, and thrombocytes (1). Blood type is defined by the presence of specific antibodies and antigens. Over three-hundred antigens on erythrocytes have been described in the literature, and the International Blood Transfusion Association lists more than 30 blood type systems (2). Among them, the ABO and Rhesus (Rh) systems were the most significant. The ABO system, discovered by Karl Landsteiner in 1900, categorizes blood types according to A and B antigens (3,4). The Rh system further classifies blood based on the presence or absence of the D antigen, resulting in Rh-positive or Rh-negative blood types (5). The distribution of blood types varies according to region, country, and ethnicity (6). In the USA, O+ is the most common blood type, whereas AB is rarer (7). Additionally, a study in Türkiye found that A+ is the most common blood type, whereas AB is the least common (8).

ABO antigens appear in many cell types and tissues, making certain blood types more susceptible to specific conditions because of their different genetic expression (9). For example, blood type O has been linked to a lower risk of otitis media due to higher antibodies against infectious agents, whereas blood type A has been associated with an increased risk of ischemic heart disease in patients with type 1 diabetes and a higher likelihood of developing oral cancer (10-12). Studies have also explored the association between blood types and coronavirus disease-2019, indicating that type A individuals may have a higher risk of infection than type O (13).

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Research into the relationship between blood type and hearing found no significant differences in hearing thresholds among blood types (14). However, other studies have shown that individuals with blood type O are more susceptible to noise-induced hearing loss (NIHL) (15-17). Continuous or sudden loud noise primarily damages the outer hair cells (OHC), and the otoacoustic emission (OAE) test serves as an objective measure of OHC function. Tracking changes in OAE amplitude can detect noise-induced damage more effectively than pure-tone hearing tests, and abnormal OAE responses can indicate increased NIHL risk (18). OAE tests are classified as spontaneous and evoked emissions. Spontaneous emissions occur without audible stimulation, whereas evoked emissions require an external signal. Among evoked emissions, transient-evoked otoacoustic emission (TEOAE) and distortion product otoacoustic emission (DPOAE) are commonly used for screening and diagnostic purposes (19). Factors such as race, age, and gender can influence OAE measurements although gender does not significantly affect responses (19-21).

Studies have shown that blood type and related antigens affect intercellular recognition during development, and this has potential implications for auditory function. Although some studies suggest blood types O and Rh+ may exhibit poorer responses to OAE, further extensive research is needed to confirm these findings (15,22). Given the demonstrated association between blood type and OAE responses, our research aimed to investigate the relationship between blood type (ABO) and Rh factors and TEOAE and DPOAE amplitudes. We aim to contribute to the limited literature on hearing loss susceptibility and blood types, hypothesizing that different blood types may be associated with varying hearing thresholds.

METHODS

Participants

This study was approved by the Local Ethics Committee of İstanbul University-Cerrahpaşa Non-invasive Clinical Research Ethics Committee under protocol 10.04.2018-134269 (decision no: 2024/42, date: 25.01.2024) and was carried out in accordance with the Declaration of Helsinki. Written informed consent to participate was obtained from all participants.

Individuals with normal otoscopic findings and middle ear function, with a hearing threshold of 15 dB and better at all frequencies between 125 Hz and 8 kHz, without a history of exposure to noise, and whose blood type was confirmed by a blood test before the study were prospectively included in the study. Participants who met the inclusion criteria were grouped according to the respective blood group. The demographic data and hearing thresholds of the patients are presented in Table 1.

Following a detailed otologic history including noise exposure, audiometric tests were performed to evaluate the range of 125-8 kHz. Patients with high-frequency hearing loss and those with NIHL configuration (4 kHz Notch) were excluded from the study.

Procedure

Otoscopic examination, acoustic immittance evaluation, and pure tone hearing tests were performed in all participants. Tympanometry, acoustic reflex, and eustachian function tests were performed using an acoustic immitancemetry device (GSI Tympstar V2-Grason-Stadler Inc. Eden Prairie, MN) to verify normal middle ear function. Hearing thresholds were measured using a calibrated clinical audiometer device (GSI Audiostar; Gram-Stadler Inc. Eden Prairie, MN) in a quiet cabinet using TDH-39P headphones in the 125 Hz-8 kHz range. An Echoport ILO 288 OAE device (Otodynamics Ltd, Hatfield, UK) was used for TEOAE and DPOAE measurements by placing a suitable silicone probe into the ear canal of the individual using 80-84 dB peSPL click stimulus and two pure tone stimuli at 65/55 dB SPL (f2/f1=1.22), respectively. The TEOAE and DPOAE tests were performed at 1-4 kHz and 1-6 kHz frequencies, respectively, as the frequencies measured in OAE equipment in clinical routine use are often measured in the range of 1-4 kHz, which is the range of communication in daily life. Patients were grouped according to ABO blood type. The amplitudes of TEOAE and DPOAE were measured in both the left and right ears of each group (ABO).

Statistical Analysis

All data were analyzed using the Statistical Packages for Social Sciences (SPSS) software version 21.0 (IBM Corp.; Armonk, NY, USA). The Kruskal-Wallis test was used for multiple group comparisons that were not normally distributed, and Dunn-Bonferroni correction was used to identify pairs with significant differences. Findings with $p<0.05$ were considered statistically significant.

Table 1. Demographic characteristics of the individuals participating in the study

Number of participants (n)	70
Male	27
Female	43
Age (mean ± SD)	21.75±1.36
Blood types	**n**
A	
Rh+	10
Rh-	9
B	
Rh+	10
Rh-	9
AB	
Rh+	10
Rh-	10
O	
Rh+	10
Rh-	2

p>0.05 air and bone conduction thresholds. SD: standard deviation

RESULTS

The study included 70 participants (43 female, 27 male) with the following blood type distribution: 19 participants had blood type A (10 Rh+ and 9 Rh-), 19 participants had blood type B (10 Rh+ and 9 Rh-), 20 participants had blood type AB (10 Rh+ and 10 Rh-), and 12 participants had blood type O (10 Rh+ and 2 Rh-). The ages of the participants ranged from 18 to 26 years (average age: 21.75 years; standard deviation: 1.36 years). The average air-conduction hearing thresholds of the participants were 5.09±3.01 dB in the right ear and 5.14±3.19 dB in the left ear. The bone conduction hearing thresholds of the participants were 3.26±2.96 dB in the right ear and 3.41±2.74 dB in the left ear.

An initial analysis of mean ranks was conducted to determine whether Rh had a significant effect on the OAE results. No statistically significant differences were observed between the same blood types with different Rh factors ($p>0.05$). Due to the lack of significant differences and the small number of participants with AB Rh blood type, subsequent analyses were conducted without considering Rh.

The TEOAE and DPOAE test results were analyzed using the Kruskal-Wallis test, which revealed a statistically significant difference in the left ear TEOAE results at 1.4 and 2 kHz ($p<0.05$). Further pairwise analysis using the Dunn test with Bonferroni correction indicated that at 1.4 kHz, the B blood type had a higher TEOAE signal-to-noise ratio (SNR) than the A ($p=0.008$) and AB ($p=0.018$) blood types. At 2 kHz, the AB blood type had a lower SNR than the O ($p=0.042$), A ($p=0.043$), and B ($p=0.002$) blood types. The descriptive statistics and statistical analysis results for the TEOAE and DPOAE tests are presented in Table 2. The DPOAE and TEOAE test results are also visualized in Figure 1.

DISCUSSION

In this study, we focused on the differences in OAE responses among ABO and Rh blood groups. In contrast to previous studies, we investigated the impact of both ABO and Rh blood types on OAE amplitudes and obtained different results. Participants with AB blood type tended to exhibit lower TEOAE and DPOAE SNR amplitudes at 2 kHz. Additionally, the TEOAE amplitudes of individuals with blood type B were higher at 1.4 kHz in the left ear than those with blood types A and AB. However, no consistent relationship was observed for the other blood groups.

The normal ear canal resonance ranges between 2 and 3 kHz, and the middle ear resonance frequency spans 800-1200 Hz in adults (23). Because the outer and middle ear systems have higher permeability to sounds at these frequencies, it is possible to record higher OAE amplitudes. Prabhu et al. (24) noted that individuals with blood type O had higher middle ear resonance frequency and ipsi/contralateral acoustic reflex thresholds compared with other blood groups. Additionally, studies have found OAE amplitudes between 1 and 3 kHz to be higher than at other frequencies (25,26). Similarly, in our study, mean OAE amplitudes tended to be higher at 1.4-2.8 kHz (Table 2).

Recent studies have suggested differences in OAE responses among adults based on ABO and Rh blood types. Chow et al. (15) classified 60 female participants with normal hearing according to ABO blood type and found no statistically significant difference between right and left ear TEOAE results at different frequencies.

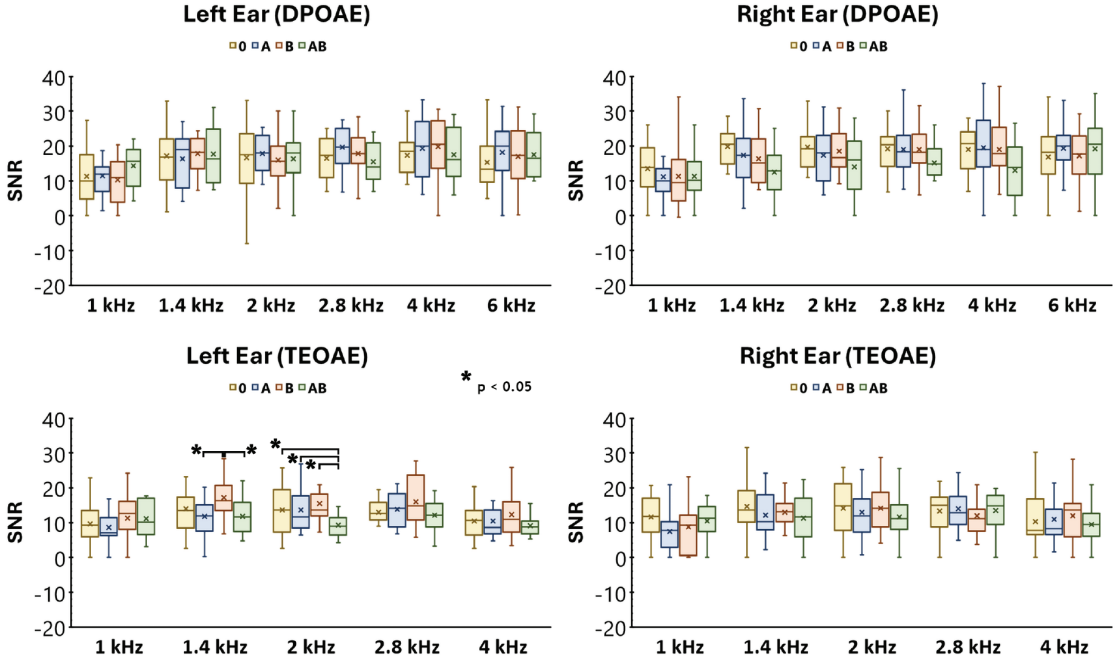

Figure 1. TEOAE and DPOAE test results for each blood type
DPOAE: distortion product otoacoustic emission, TEOAE: transient evoked otoacoustic emission

Table 2. Descriptive statistics and statistical comparisons of the DPOAE and TEOAE test results according to blood type

	0 type			A type			B type			AB type			p-value (inter-group)
	N	M	IQR	N	M	IQR	N	M	IQR	N	M	IQR	
Left ear DPOAE													
1 kHz	20	10.00	11.00	19	10.00	6.00	19	11.00	9.00	12	18.00	10.00	0.553
1.4 kHz	20	16.85	10.75	19	19.00	14.50	19	19.30	6.05	12	16.70	14.60	0.932
2 kHz	20	17.45	12.83	19	18.00	8.60	19	19.00	13.30	12	17.00	8.20	0.728
2.8 kHz	20	17.40	8.00	19	21.00	8.85	19	19.60	9.20	12	14.00	9.65	0.299
4 kHz	20	17.50	9.75	19	20.00	14.00	19	22.30	10.70	12	15.00	17.40	0.604
6 kHz	20	12.65	12.08	19	20.00	11.55	19	17.40	11.05	12	17.00	13.15	0.412
Right ear DPOAE													
1 kHz	20	14.50	9.95	19	8.00	7.30	19	10.40	14.25	12	10.60	8.25	0.435
1.4 kHz	20	20.50	6.68	19	16.00	11.50	19	19.80	10.10	12	14.00	6.80	0.070
2 kHz	20	19.10	8.75	19	18.20	13.50	19	22.10	13.80	12	16.00	11.70	0.411
2.8 kHz	20	20.45	9.02	19	19.00	7.50	19	20.60	9.10	12	14.40	9.10	0.557
4 kHz	20	20.60	10.60	19	19.00	9.50	19	19.20	8.90	12	14.00	11.40	0.268
6 kHz	20	17.60	10.75	19	21.00	7.00	19	17.60	11.45	12	22.00	12.25	0.682
Left ear TEOAE													
1 kHz	20	9.55	8.00	19	7.10	4.00	19	13.20	8.00	12	10.00	10.00	0.195
1.4 kHz	20	12.85	12.53	19	11.30	7.90	19	18.90	10.35	12	11.20	6.50	0.030*
2 kHz	20	13.70	12.83	19	11.10	9.10	19	17.40	7.65	12	7.60	5.10	0.026*
2.8 kHz	20	12.55	4.50	19	14.40	7.95	19	16.90	13.15	12	13.50	6.95	0.439
4 kHz	20	7.40	6.30	19	8.30	6.40	19	11.00	13.20	12	9.20	3.35	0.859
Right ear TEOAE													
1 kHz	20	11.85	8.00	19	7.80	6.00	19	10.20	10.00	12	12.20	6.00	0.074
1.4 kHz	20	12.55	8.95	19	10.30	7.35	19	13.20	7.15	12	12.10	7.70	0.344
2 kHz	20	14.10	10.85	19	11.40	7.60	19	12.00	9.05	12	11.00	7.15	0.587
2.8 kHz	20	14.95	6.80	19	13.60	9.40	19	11.10	9.35	12	15.10	4.85	0.319
4 kHz	20	7.70	4.80	19	7.50	6.50	19	13.70	11.65	12	9.70	8.80	0.721

N: sample size, M: median, IQR: interquartile range, *p<0.05, DPOAE: distortion product otoacoustic emission, TEOAE: transient evoked otoacoustic emission

However, individuals with blood type O exhibited lower TEOAE amplitudes at 1.0, 1.4, and 4.0 kHz in the left ear and 1.4, 2.8, and 4.0 kHz in the right ear compared with the other blood types (15). In a similar study, Chen et al. (22) showed that the TEOAE and DPOAE amplitudes of 60 male participants varied significantly across the four blood types, with individuals having blood type O showing lower OAE amplitudes.

In another study by Prabhu et al. (27), the association between blood type differences and high-frequency hearing sensitivity were examined using high-frequency hearing and DPOAE tests. The findings indicated that although there was no significant difference in high-frequency hearing thresholds, individuals with blood type O exhibited lower DPOAE amplitudes. It has been suggested that these results might be due to the presence of fewer active OHC in individuals with blood type O (27). Although previous studies have shown that individuals with blood type O exhibited lower OAE amplitudes than those with other blood types, our study did not confirm a consistent pattern.

Another important factor in blood transfusion is the Rh system. Blood-type antigens are transiently expressed during the development of hair cells in the cochlea, influencing processes like hair cell development, synaptogenesis, and ciliogenesis, which are associated with the Rh system (20). Few studies have investigated the effects of the Rh factor on auditory function. Bener et al. (28) found a positive relationship between Rh+ blood type and hearing loss in infants. Conversely, Ayçiçek et al. (29) indicated that workers with Rh+ blood type were more likely to develop NIHL than those with Rh blood type. However, another study concluded that although blood type may be an individual risk factor for hearing loss, Rh antigens were not considered risk factors (30). Li et al. (31) did not examine the effect of Rh on OAE results because Rh- blood type is present in only 0.9% of cases. In our study, no significant difference was found between the DPOAE and TEOAE amplitudes of individuals with Rh+ and Rh blood types ($p>0.05$). Our research aims to contribute to the literature by examining the association between Rh antigens and hearing status.

Other studies investigating the effects of ABO blood types on the auditory system have yielded contradictory results. Although some studies, such as those by Doğru et al. (16) and Nair and Kashyap (17), suggested a correlation between ABO blood types and NIHL, Ayçiçek et al. (29) found no significant difference. Factors like race and gender may also influence OAE responses, but there are no clear data on their relationship to OAEs in the literature. Structural differences, such as the length of the external ear canal, tympanic membrane, middle ear ossicles, and cochlea, might also affect OAE responses. In our study, gender and race were not proven to influence OAEs; thus, we did not consider these factors during evaluation.

In conclusion, our study investigated the association between ABO and Rh blood systems and OAE amplitudes and found different results compared with those reported for both TEOAE and DPOAE amplitudes across blood types. Unlike other studies that generally compared blood type O with others, our study included all ABO types and analyzed subgroups (Rh, right/left ear, DPOAE/TEOAE), providing more detailed information on the association between blood types and OAEs.

Study Limitations

The limitations of our study include the limited number of patients included in the analysis, failure to evaluate the effectiveness of the efferent system, anatomical differences, and the exclusion of gender factors due to the small number of participants. Although the ages of the individuals included in our study were similar, it is possible that age differences or exposure to unknown noise and ototoxicity may produce results that differ from those in the literature.

CONCLUSION

In our study, unlike many reports in the literature, the TEOAE and DPOAE SNR amplitudes tended to be lower for the AB blood type than for the other blood types. This difference may be due to all subjects in our sample were of the same race. In a larger group of subjects of different races, it will be possible to determine whether this is a racial variation. Measuring the potential produced by the OHC with DPOAE and TEOAE in subjects with different blood types, Rh factors, and right/left ears at different frequencies was thought to induce a better understanding of the differences in OAE among subjects. Various factors, such as the relatively large volume of the ear canal, mass of the ossicular chain, resonant frequency of the middle ear, and contralateral suppression, may affect OAEs. Conducting studies with larger groups may provide more consistent and generalizable information and shed light on individual differences.

Ethics Committee Approval: This study was approved by the Local Ethics Committee of İstanbul University-Cerrahpaşa Non-invasive Clinical Research Ethics Committee under protocol 10.04.2018-134269 (decision no: 2024/42, date: 25.01.2024) and was carried out in accordance with the Declaration of Helsinki.

Informed Consent: Written informed consent to participate was obtained from all participants.

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