Original Article

The effect of body mass index on traditional 226 Hz tympanometry and wideband tympanometry test results

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ABSTRACT

Objectives: The aim of this study was to investigate the possible effects of body mass index (BMI) on traditional 226 Hz tympanometry and wideband tympanometry (WBT) to gain a better understanding of resonance frequency.

Patients and Methods: A total of 158 ears of 79 volunteers (19 males, 60 females; mean age: 20.5 years; range, 18 to 27 years) who had normal hearing and normal otoscopic examination findings were included in the study between October 2019 and June 2020. By measuring the weight and height of the participants, their BMI values were classified into three groups: ≤18.5 kg/m^2 (underweight), 18.5 to 24.9 kg/m^2 (normal weight), and ≥25.0 kg/m^2 (overweight). Tympanometric evaluations were conducted using the Interacoustics-Titan WBT.

Results: The difference of ear canal volume (ECV) was significant between the two sexes ($p<0.05$), while there was no significant difference in the tympanometric peak pressure, compliance, gradient, and resonance frequency between the sexes ($p>0.05$). A significant difference was found in the ECV and resonance frequency among the three BMI groups ($p<0.05$). Accordingly, as the BMI increased, the ECV increased and the resonance frequency decreased ($p<0.05$).

Conclusion: The BMI may affect ECV and resonance frequency values which should be considered during the examination.

Keywords: Acoustic impedance tests, body mass index, ear canal volume.

Acoustic immittancemetry measurements are the most sensitive and appropriate techniques used for evaluation of the middle ear. They are fast and non-invasive responses to the tone and pressure changes given in the middle ear. It is an objective evaluation method based on the measurement of these responses by microphone.[1] Currently, traditional 226 Hz tympanometry is commonly used in audiology clinics. In the evaluation of tympanometry in adults, a probe tone with a frequency of 226 Hz and 85 dB sound pressure level (SPL) is given through the outer ear canal.[2] Tympanometric peak pressure (TPP), compliance, ear canal volume (ECV), and gradient are assessed.[1]

The wideband tympanometry (WBT) provides an evaluation of the frequencies between 220 and 8,000 Hz. It provides information about the resonance frequency (RF) that the traditional 226 Hz tympanometry fails to deliver. The RF is the frequency at which the mass and stiffness properties of the middle ear are equal. The admittance, which is the conduction of the sound energy, of the middle ear is at the

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maximum level at this frequency. The WBT evaluation is considered to be more sensitive in the diagnosis of middle ear diseases than the 226 Hz tympanometry evaluation.[3]

The body mass index (BMI) is obtained by dividing the weight (kg) by the square of the height (m^2). According to the results of the calculation, BMI is classified as follows: ≤18.5 kg/m^2 (underweight), 18.5 to 24.9 kg/m^2 (normal weight), 25 to 29.9 kg/m^2 (pre-obesity), and ≥30 kg/m^2 (obesity).[4] The alterations in the BMI may affect many functions of organs and systems in human.[4] With the increased BMI, subcutaneous fat accumulation in the head and neck region is also frequent, as in the other organs and tissues.

In the present study, we aimed to investigate the possible effects of BMI on traditional 226 Hz tympanometry and WBT measurements to gain a better understanding of RF.

PATIENTS AND METHODS

The prospective cohort study was conducted at Istanbul Medipol University, Faculty of Health Sciences South Campus, Audiology Laboratories between October 2019 and June 2020. A total of 158 ears of 79 participants (19 males, 60 females; mean age: 20.5 years; range, 18 to 27 years) who had no problems of hearing loss and had normal otoscopic examination findings were included. Those who did not meet the inclusion criteria and who had external or middle ear problems, a flu within the last seven days, and/or a recent history of a cold were excluded from the study. Demographic and clinical characteristics of the participants were recorded. Prior to study, all participants were informed about the nature of the study and a written informed consent was obtained. The study protocol was approved by the Istanbul Medipol University Ethics Committee (No. 2019/675). The study was conducted in accordance with the principles of the Declaration of Helsinki.

The tympanometry evaluation of the participants was performed using the Interacoustics-Titan WBT tympanometry device (Interacoustics A/S, Middelfart, Denmark). To perform a tympanometry measurement, a probe was placed into the ear canal using an appropriately sized ear tip. While inserting the probe in the outer ear canal, special care was taken not to block the ear tip at some point in the outer ear canal and to fit the canal completely. The participants were not allowed to speak or swallow during the evaluation and informed about that they would feel a sound and pressure during the application. First, 266 Hz tympanometry measurement was performed, recording the TPP, compliance, ECV, and gradient values for both ears. Then, the WBT evaluations were performed and RF values were recorded in the same way for both ears. To calculate the BMI, the weight and height of each participant were measured and recorded by the researchers. The participants were divided into three groups according to BMI values as follows: ≤18.5 kg/m^2 (underweight), 18.5 to 24.9 kg/m^2 (normal weight), and ≥25.0 kg/m^2 (overweight).

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency, where applicable. The Kruskal-Wallis test was to determine significant differences among the groups. The Mann-Whitney U test was carried out to compare ECV and RF among the BMI groups. Regression analysis was performed to examine any relationship between BMI and tympanometry measurements. A p value of <0.05 was considered statistically significant.

RESULTS

Baseline demographic characteristics of the participants are shown in Table 1.

The BMI values of the participants were calculated and divided into three groups. There were 11 participants in the underweight group,

Table 1. Descriptive statistics of the participants

	n	Mean±SD	Min-Max
Age (year)	79	20.5±1.8	18.00-27.00
Weight (kg)	79	63.1±12.7	40.20-90.90
Height (m)	79	1.7±.1	1.53-1.85

SD: Standard deviation; Min: Minimum; Max: Maximum.

Table 2. Pressure, compliance, ear canal volume, gradient and resonance frequency according to BMI groups

		Pressure (daPa)	Compliance (mL)	Ear canal volume (cm^3)	Gradient (daPa)	Resonance frequency (Hz)
		Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
BMI Groups (kg/m^2)	≤18.5	-1.5±6.3	0.5±0.2	1.1±0.2	82.8±19.9	978.7±264.0
	18.5-24.9	-3.4±11.1	0.7±0.5	1.2±0.3	89.2±26.8	923.4±277.5
	≥25.0	-3.7±16.5	0.7±0.3	1.3±0.3	83.4±16.0	827.5±158.6
p values		0.485	0.141	0.008**	0.308	0.011*

SD: Standard deviation; * p<0.05; ** p<0.01; Kruskal-Wallis test.

47 participants in the normal weight group, and 21 participants in the overweight group. The TPP, compliance, ECV, gradient and RF data were evaluated according to sex, right-left ear, and BMI groups using 226 Hz tympanometry and WBT in each participant.

All tympanometry values were initially compared for sex effects. A statistically significant difference (p=0.008) was observed for only ECV. There was no statistically significant difference between the right-left ear tympanometric values.

Table 2 shows the comparisons of all parameters according to BMI, except for sex and righ/left ears. As a result of this analysis, there was no significant difference among the BMI groups in TPP, compliance, and gradient parameters (p>0.05). There was a significant difference among the BMI groups in terms of ECV (p=0.008) and RF (p=0.011).

There was a significant difference in the ECV between the BMI ≤18.5 kg/m^2 and 18.5 to 24.9 kg/m^2 groups (p=0.010) and between the BMI ≤18.5 kg/m^2 and BMI ≥25.0 kg/m^2 groups (p=0.003). However, there was no significant difference between the BMI 18.5 to 24.9 kg/m^2 and ≥25.0 kg/m^2 groups (p=0.236).

For the RF, there was no significant difference between the BMI ≤18.5 kg/m^2 and 18.5 to 24.9 kg/m^2 groups (p=0.245). However, a significant difference was found between the BMI ≤18.5 kg/m^2 and BMI ≥25.0 groups (p=0.009) and between the BMI 18.5 to 24.9 kg/m^2 ≥25.0 groups (p=0.014).

The effects of numerical value of BMI on TPP, compliance, ECV, gradient and RF were analyzed by simple regression method, regardless of the right-left ear direction and sex. Accordingly, the effect of BMI on ECV and RF was found to be significant. While the BMI affected the ECV in the same direction, it affected the RF in the opposite direction. Regression coefficients were 0.016 for ECV and -12.464 for RF. Accordingly, as the BMI increased, the ECV increased and the RF decreased.

DISCUSSION

In the present study, the effects of BMI on tympanometry and WBT values were investigated. Using tympanometry and WBT to individuals with healthy middle ears, TPP, compliance, ECV, gradient and RF results were determined. The differences of these results among the BMI groups were investigated. Our study results showed that ear canal volume increased with the increse of BMI while resonance frequency values showed a decrease.

There are studies showing that acoustic immittance measurements may differ according to age, sex, right-left ear (ear direction). In a study in which the tympanometric data of Chinese adults were examined, a significant difference was found in the ECV value between two sexes; however, the TPP, compliance, and gradient values did not significantly differ.[5] Similarly, in our study, we observed that the ECV was statistically significantly smaller in women compared to men, although no statistically significantly difference was found in the other variables.

In a study, Polat et al.[6] used WBT normative data in young Turkish adults. This study, for the first time, revealed that these variables did not significantly differ between the right and left ears. As a result of the statistical analysis, however, there was a significant difference in the ECV and RF between male and female participants. In addition, this study proved a strong correlation between the body size and ECV.[6] In another study determining normative values of WBT, RF did not show a significant difference according to sex.[7] In addition, a study investigating the effect of septum deviation on middle ear RF reported that RF was not affected by sex and age.[8] In a similar study, RF could be affected by sex and right-left ear (ear direction).[9] In our study, the change of RF by sex and right-left ear side was found to be statistically non-significant.

Furthermore, Mazlan et al.[10] evaluated different age groups and sexes with WBT values including 40 young adults, 31 middle-aged and 30 elderly individuals. In this study, compliance, ECV, and TPP were analyzed and no significant difference was found according to age or sex. Shahnaz and Davies[11] included 83 Chinese and 78 Caucasian young adults in their study to determine standard and multifrequency tympanometry norms. The effect of sex was evaluated for ECV and found to be significant. The authors also demonstrated that their body size significantly affected the ECV, although no significant difference was observed in other variables. In the same study, sex effect was evaluated for TPP, static admittance (SA), and gradient, indicating no significant result. In our study, there was a significant difference in the ECV values among the three BMI groups. Accordingly, the mean±SD ECV values were 1.1±0.2 cm^3 in the BMI ≤18.5 kg/m^2 group, 1.2±0.3 cm^3 in the BMI 18.5 to 24.9 kg/m^2 group, and 1.3±0.3 cm^3 in the BMI ≥25.0 kg/m^2 group. In the BMI ≤18.5 kg/m^2 group, the mean ECV value was significantly lower than the other groups. The RF was also analyzed among different age groups in the Turkish population. In a study, the RF value of 150 participants (300 ears, 66 men and 84 women) was analyzed; however, no statistically significant difference in the RF between the right and left ears and between males and females was observed.[7]

In the literature, there are several studies regarding the effect of weight or BMI on hearing physiology and, eventually, on tympanometric evaluations. In a study investigating the relationship between effusion otitis media (EOM) and BMI, obesity was associated with the development of EOM in the pediatric group.[12] In another study including 78 participants with normal hearing, the participants were divided into three groups according to BMI values and RF was examined.[13] There was a statistically significant difference in the RF values with an inverse relationship between the BMI and RF. Similarly, in our study, the difference in RF among the BMI groups was statistically significant and there was an inverse relationship between the BMI and RF; i.e., as the BMI increased, the RF decreased. In our study, we also observed that there was a statistically significant difference in the ECV values among the BMI groups, showing that the BMI had the same directional relationship with the ECV, and the ECV value increased, as the BMI increased. This has been associated with the change in the ECV value, changing the RF, as well.[14]

In the present study, we found a significant difference in the RF values among the BMI groups. Accordingly, the mean±SD RF values were 978.7±264.0 Hz in the BMI ≤18.5 kg/m^2 group, 923.4±277.5 Hz in the BMI 18.5 to 24.9 kg/m^2 group, and 827.5±158.6 Hz in the BMI ≥25 kg/m^2 group. In the BMI ≥25 kg/m^2 group, the RF value was significantly lower than the other groups.

To the best of our knowledge, there is a limited number of studies regarding the effects of BMI on 226 Hz tympanometry and WBT measurements. At the time of this study, the education was interrupted indefinitely on March 16th, 2020 due to the novel coronavirus-2019 (COVID-19) pandemic, which dramatically affected the whole world. This situation created restrictions in the data of the participants and affected our study. Although we contributed to the literature with the data we obtained in our study, the fact that the number of participants in our BMI groups did not show a homogeneous distribution. Therefore, more detailed and homogeneous studies should be carried out with these parameters.

In conclusion, there was a significant difference in the ECV and RF values among the three BMI groups as measured by traditional 226 Hz tympanometry or WBT. Based on these findings, we conclude that some parameters used in the immitansmetric mesurements may be affected by varying BMI values and, thus, further studies are needed to examine the normative data of 226 Hz tympanometry and WBT parameters. Nevertheless, this study showed that body sizes should be taken into consideration during the evaluation of these tests used in the audiology clinic.

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REFERENCES

1. Yücel E. Pozisyona Bağlı İntralabirentin Basınç Değişikliklerinin Geniş Bant Timpanometri ve Distortion Product Otoakustik Emisyon Testi Üzerine Etkileri. [Uzmanlık Tezi], Denizli; Pamukkale Üniversitesi Tıp Fakültesi Kulak Burun Boğaz ve Baş Boyun Cerrahisi Anabilim Dalı; 2017.
2. Ogut F, Serbetcioglu B, Kirazli T, Kirkim G, Gode S. Results of multiple-frequency tympanometry measures in normal and otosclerotic middle ears. Int J Audiol 2008;47:615-20.
3. Hunter LL, Sanford C. Tympanometry and Wideband Acoustic Immittance. In: Katz J, Chasin M, English K, Hood L, Tillery K, editors. Handbook of Clinical Audiology. 7th ed. Philadelphia: Wolters Kluwer; 2004. p. 137-63.
4. WHO/Europe | Nutrition - Body mass index - BMI [Internet]. Available at: https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi
5. Manchaiah V, Durisala N, Marimuthu V. Tympanometric profiles for Chinese older adults. Audiol Res 2017;7:190.
6. Polat Z, Baş B, Hayır D, Bulut E, Ataş A. Wideband tympanometry normative data for turkish young adult population. J Int Adv Otol 2015;11:157-62.
7. Özgür A, Müjdeci B, Terzi S, Özergin Coşkun Z, Yiğit E, Dursun E. Wideband tympanometry normative data for different age groups in Turkish population. J Int Adv Otol 2016;12:82-6.
8. Güldüz M, Akdoğan MV, Büyüklü F. Septum deviasyonunun orta kulak rezonans frekansı üzerine etkisi: Prospektif klinik çalışma. KBB ve BBC Dergisi 2018;26:12-6.
9. Sezin RK, Hızal E, Erbek S, Özlüoğlu LN. Normative values of middle ear resonance frequency in normal hearing adults. Kulak Burun Bogaz Ihtis Derg 2013;23:331-5. Turkish.
10. Mazlan R, Kei J, Ya CL, Yusof WN, Saim L, Zhao F. Age and gender effects on wideband absorbance in adults with normal outer and middle ear function. J Speech Lang Hear Res 2015;58:1377-86.
11. Shahnaz N, Davies D. Standard and multifrequency tympanometric norms for Caucasian and Chinese young adults. Ear Hear 2006;27:75-90.
12. Kim SH, Park DC, Byun JY, Park MS, Cha CI, Yeo SG. The relationship between overweight and otitis media with effusion in children. Int J Obes (Lond) 2011;35:279-82.
13. Sözen M, Öz I, Erbek S. Effect of body mass index on middle ear resonance frequency. J Int Adv Otol 2018;14:208-10.
14. Kılıç S, Çiçek Çınar B, Sennaroğlu G. Çocuklarda eşdeğer kulak kanalı hacmi değerlerinin yaşa göre değişiminin incelenmesi. TJAHR 2019;2:10-13.