



Research Paper

Establishing Wideband Tympanometry Clinical Normative Data for the Iranian Young Adult Population



Mohsen Ahadi^{1*}, Nasrin Yazdani²

1. Department of Audiology, Rehabilitation Research Center, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran.
2. Department of Otorhinolaryngology, Otorhinolaryngology Research Center, School of Medicine, Amir-Alam Hospital, Tehran University of Medical Sciences, Tehran, Iran.



Copyright: © 2024 The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Article info:

Received: 19 Jul 2024

Accepted: 18 Aug 2024

Available Online: 17 Sep 2024

ABSTRACT

Background and Objectives: This study aims to develop a normative data for wideband acoustic immittance (WBT) in the Iranian young adults. WBT is a new method for assessing middle ear status using a wide spectrum stimulus instead of the traditional 226 Hz probe tone.

Methods: In this study, 20 healthy Iranian young adults with normal auditory and neurologic function underwent WBT measurement in a quiet place by presenting a wideband click stimulus at an intensity 100 dB peSPL. Different WBT parameters including power absorbance and resonance frequency (RF) of the middle ear in two conditions with and without pressure were calculated.

Results: There were differences in quantitative WBT parameters including power absorbance and RF of the middle ear, compliance, external ear canal volume, Tympanogram gradient, and tympanogram peak pressure at 226, 678, 800, and 1000 Hz, emphasizing the importance of using ethnicity-specific norms in clinical evaluations.

Conclusion: The findings can help in diagnosing various middle ear disorders and monitoring treatment progress.

Keywords: Wideband acoustic immittance, Normative data, Middle ear, Tympanometry, Iranian population



Cite this article as Ahadi M, Yazdani N. Establishing Wideband Tympanometry Clinical Normative Data for the Iranian Young Adult Population. Function and Disability Journal. 2024; 7:E40.1. <http://dx.doi.org/10.32598/fdj.7.40.1>

doi <http://dx.doi.org/10.32598/fdj.7.40.1>

* Corresponding Author:

Mohsen Ahadi, Associate Professor.

Address: Department of Audiology, Rehabilitation Research Center, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran.

Tel: +98 (21) 22250541

E-mail: mohsenahadi@gmail.com

↑ *What is “already known” in this topic:*

Several normative data sets are available in different parts of the world about wideband tympanometry, but these norms are gender and ethnicity specific.

→ *What this article adds:*

This article provides normative data for wideband acoustic immittance (WBT) in Iranian young adults which can assist clinicians in diagnosing various middle ear disorders and monitoring treatment progress.

Introduction

Wideband acoustic immittance or wideband tympanometry (WBT) is an emerging tool used to examine the middle ear condition, ossicular chain, and tympanic membrane mobility [1]. A single wide spectrum stimulus “click” instead of the traditional 226 Hz probe tone is presented to the ear canal and hundreds of tympanograms from 226 to 8000 Hz could be visualized in a 3D format. This method permits complete analysis of middle ear conditions over a wide range of frequencies that encompass the full range of speech signals. Moreover, the acoustic energy absorbance of the middle ear and resonance frequency (RF) will be calculated [2]. Therefore, the clinical advantage of WBT is to increase the diagnostic precision of middle ear disorders and conditions and to increase the sensitivity and specificity of the test compared to traditional immittance measurements. Recent results show that different middle ear pathologies can affect the normal energy absorbance and RF in different ways [3]. Although several studies reported their normative values of WBT [4, 5], some other reports show that ethnic, gender, and age differences are a source of variability to the norms, and utilizing the same norm can cause erroneous results [6, 7]. For instance, according to Shahnaz et al., Caucasians have a higher peak pressure, larger ear canal, and narrower tympanic cavity than Asians [7]. Hunter and Shahnaz also reported that the Chinese population mainly had smaller admittance and ear canal volume, a more positive tympanogram peak pressure (TPP), and larger track width (TW) values [8]. Hence, the current study was conducted to investigate and collect the normal characteristics of clinical WBT measurement in the Iranian young adult population. Having our ethnic-specific norms can help clinicians to determine the middle ear conditions and disease more accurately. This report will provide preliminary data from a larger study con-

ducted at Iran University of Medical Sciences to explore the sequel of various middle ear pathologies on WBT normative data.

Materials and Methods

Twenty healthy students from the School of Rehabilitation Sciences, Iran University of Medical Sciences (8 females, and 12 males) with a Mean±SD age of 26.9±6.21 years were registered to participate in this descriptive cross-sectional study. All subjects had a clear history of auditory, learning, and neurologic function. All had normal otoscopic examinations, and well-functioning middle ear status (confirmed with traditional immittance results) and had normal pure tone thresholds (air conduction thresholds of better than 20 dB HL in the range of 250–8000 Hz). Subjects gave written consent to take part in the study. All the participants enrolled in the study had Iranian ethnic origin.

The Interacoustics Titan version 3.1 (IMP440, Denmark) was first calibrated as specified by IEC 60645-5/ANSI S3.39, type 1 standards. Afterward, an appropriate probe tip (CIR 55-INSERT) was inserted in the external auditory meatus and 100 dB peSPL (almost equal to 65 dB nHL) click stimulus was presented to the ear in a quiet audiometry cabin to calculate the wideband acoustic immittance parameters in the frequency range of 226 to 8000 Hz. Participants were asked to stay still and pressure inside the ear canal was changed from +200 to -400 dapa, with 200 dapa/s pump speed. WBT estimations included RF of the middle ear, power absorbance, and other tympanometric data. Power absorbance is the total energy entered into the middle ear. The measured RF is the resonance frequency of the middle ear and is recorded at middle ear pressure. The average tympanograms, which are a flat trace showing the amount of energy absorbance in the range of 375–2000 Hz were also calculated. The benefit of taking wideband-averaged

Table 1. Descriptive statistics of tympanometric parameters at routine frequencies for test participants

Tympanometric Parameters	No.	Mean±SD	Minimum	Maximum
External ear canal volume	226	1.53±0.22	1.1	1.93
Compliance (mL)	226	0.71±0.24	0.2	1.3
	678	1.22±0.45	0.4	2
	800	1.19±0.41	0.4	1.8
	1000	1±0.41	0.2	1.6
Tympanogram gradient (dapa)	226	78.25±16.4	54	115
	678	73.4±10.57	51	97
	800	73.4±10.57	51	97
	1000	94.7±20.87	62	14
Tympanogram peak pressure (dapa)	226	-6.5±4.08	-37	20
	678	-3.05±5.13	-40	38
	800	-2.25±2.71	-30	16
	1000	14.05±6.18	-30	102

tympanograms is to include information for numerous frequencies, and also less sensitivity to noise or patient movement. Therefore, the wideband-averaged tympanograms build a more consistent and clearer view of the middle ear status.

Results

Quantitative parameters of wideband acoustic immittance, including compliance (mL), external ear canal volume (cc), tympanogram gradient (dapa), and tympanogram peak pressure (TPP) at 226, 678, 800, and 1000 Hz were extracted and descriptive statistics were summarized in Table 1. Besides, Table 2 presents the measurement of resonance frequency and dedicated immittance parameters. Figure 1 shows the spread of

power absorbance values over a range of frequencies. This Figure shows both pressurized and non-pressurized amounts of energy absorbance and percent ratios of all subjects in the frequency range of 226–8000 Hz. Figure 2 shows wideband-averaged tympanograms in the frequency range of 375–2000 Hz.

Discussion

The results of previous studies show significant differences in WBT parameters, including resonance frequency, middle ear energy absorbance curve, and other quantitative tympanometric parameters in different populations. Also, WBT (absorbance over a range of pressure) carries crucial data that is not present in single-frequency tympanometry. Therefore, it is necessary to

Table 2. Descriptive statistics of tympanometric parameters at RF for test participants

RF and Tympanometric Parameters	Mean±SD	Minimum	Maximum
RF	748.35±9.06	632	932
External ear canal volume at RF	1.51±0.24	1	1.93
Compliance (mL) at RF	1.38±0.27	0.9	2.1
Tympanogram gradient (dapa) at RF	84.65±15.32	61	117
Tympanogram peak pressure (dapa) at RF	6.9±8.1	-23	114

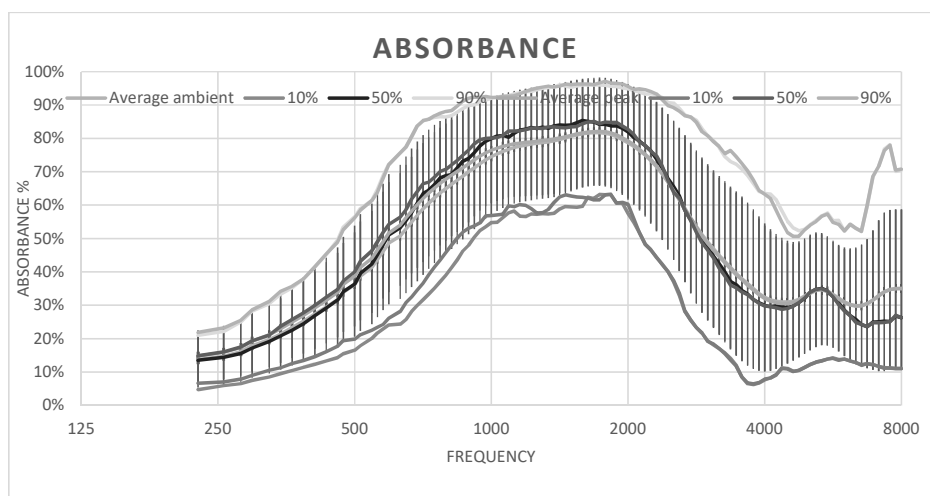


Figure 1. Distribution of pressurized and non-pressurized absorbance values and percentage ratios across 226-8000 Hz

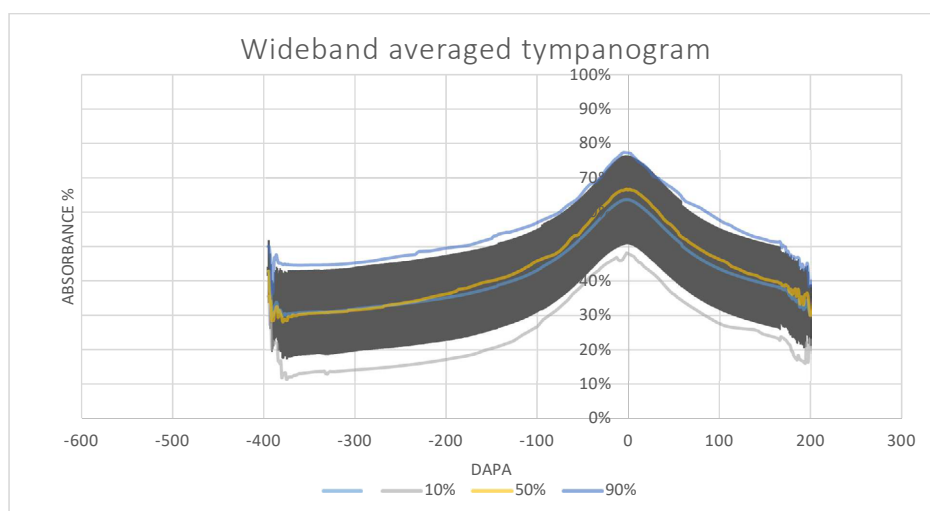


Figure 2. The percentiles of averaged wideband tympanogram

measure clinical normative values in different ethnicities to make a more appropriate clinical judgment about the status of the middle ear and also to increase diagnostic accuracy in middle ear pathologies. Therefore, in the present study, wideband acoustic immittance values were measured and reported in the young Iranian population. The observed differences in various parameters of WBT between the current research and other papers can be attributed to the different ethnicities of the tested population. For example, the mean RF of the human middle ear system with air conduction excitation is between 0.8–1.2 kHz [8, 9], while the average resonance frequency of the middle ear in the Iranian ethnicity is lower and was measured in the range of 632 to 932 Hz. In another comparison, the range of the normative acous-

tic admittance in the adult population is traditionally considered between 0.3 and 1.6 mmho [8, 10], but the present study showed that this range is in the range of 0.2 to 1.3 mmho in the Iranian population. Therefore, the results of this study highlight the importance of using specific clinical normative values of Iranian individuals, which can be used as a part of the basic clinical evaluations in audiology. Also, paying attention to the normative values increases the power of differential diagnosis of middle ear disorders, including otitis media, ossicular chain fixation, ossicular discontinuity, and tympanic membrane perforation, and makes it possible to check the progress of the disease or the process of its treatment.

Ethical Considerations

Compliance with ethical guidelines

The study method was approved by the deputy of research, Iran University of Medical Sciences, Tehran, Iran (Code: IR.IUMS.REC.1398.420).

Funding

This work was supported by the Iran University of Medical Sciences, Tehran, Iran (Code: 98-2-75-15036).

Authors' contributions

All authors equally contribute to preparing all parts of the research.

Conflict of interest

The authors declared no conflict of interest.

Acknowledgments

The authors like to convey our appreciation to all the individuals who participated in the study.

References

- [1] Sanford CA, Hunter LL, Feeney MP, Nakajima HH. Wideband acoustic immittance: Tympanometric measures. *Ear Hear.* 2013; 34(Suppl1):65S-71S. [DOI:10.1097/AUD.0b013e31829c7250] [PMID]
- [2] Margolis RH, Saly GL, Keefe DH. Wideband reflectance tympanometry in normal adults. *J Acoust Soc Am.* 1999; 106(1):265-80. [DOI:10.1121/1.427055] [PMID]
- [3] Kim SY, Han JJ, Oh SH, Lee JH, Suh MW, Kim MH, et al. Differentiating among conductive hearing loss conditions with wideband tympanometry. *Auris Nasus Larynx.* 2019; 46(1):43-49. [DOI:10.1016/j.anl.2018.05.013] [PMID]
- [4] Polat Z, Bas B, Hayir D, Bulut E, Atas A. Wideband tympanometry normative data for Turkish young adult population. *J Int Adv Otol.* 2015; 11(2):157-62. [DOI:10.5152/iao.2015.809] [PMID]
- [5] Hougaard DD, Lyhne NM, Skals RK, Kristensen M. Study on wideband tympanometry and absorbance within a Danish cohort of normal hearing adults. *Eur Arch Otorhinolaryngol.* 2020; 277(7):1899-905. [DOI:10.1007/s00405-020-05909-9] [PMID]
- [6] Shahnaz N, Feeney MP, Schairer KS. Wideband acoustic immittance normative data: Ethnicity, gender, aging, and instrumentation. *Ear Hear.* 2013; 34 (Suppl 1):27S-35S. [DOI:10.1097/AUD.0b013e31829d5328] [PMID]
- [7] Shahnaz N, Bork K. Wideband reflectance norms for Caucasian and Chinese young adults. *Ear Hear.* 2006; 27(6):774-88. [DOI:10.1097/01.aud.0000240568.00816.4a] [PMID]
- [8] Hunter LH, Shahnaz N. Wideband reflectance principles. Acoustic immittance measures. San Diego: Plural Publishing; 2014 [Link]
- [9] Homma K, Du Y, Shimizu Y, Puria S. Ossicular resonance modes of the human middle ear for bone and air conduction. *J Acoust Soc Am.* 2009; 125(2):968-79. [DOI:10.1121/1.3056564] [PMID] [PMCID]
- [10] Stach BA, Ramachandran V. Clinical audiology: An introduction. San Diego: Plural Publishing; 2021. [Link]

مقاله پژوهشی



تعیین مقادیر هنجار بالینی تمپانومتري عريض باند در جمعیت بزرگسال ایرانی

* محسن احدی^۱، نسرین یزدانی^۲

۱. گروه شنوایی شناسی، مرکز تحقیقات توانبخشی، دانشکده علوم توانبخشی، دانشگاه علوم پزشکی ایران، تهران، ایران.
۲. گروه گوش و حلق و بینی، مرکز تحقیقات گوش و حلق و بینی، دانشکده پزشکی، بیمارستان امیرعلم، دانشگاه علوم پزشکی تهران، تهران، ایران.

چکیده

مقدمه: این مطالعه بر ایجاد داده‌های هنجار برای آزمون تمپانومتري عريض باند در جمعیت جوان ایرانی تمرکز دارد. تمپانومتري عريض باند یک روش جدید برای ارزیابی وضعیت گوش میانی با استفاده از یک محرک پهن باند به جای پروب تون مرسوم ۲۲۶ هرتز است. **مواد و روش‌ها:** در این پژوهش ۲۰ جوان ایرانی با عملکرد شنوایی و عصبی هنجار تحت اندازه‌گیری WBTP قرار گرفتند. آزمایش در سکوت و با ارائه یک کلیک باند پهن در شدت ۱۰۰ دسی‌بل peSPL انجام شد. پارامترهای مختلف ایمیتانس آکوستیک عريض باند از جمله جذب انرژی و فرکانس تشدید گوش میانی در هر دو شرایط با تغییر فشار و بدون تغییر فشار محاسبه شد. **یافته‌ها:** نتایج تفاوت‌هایی را در پارامترهای کمی ایمیتانس آکوستیک عريض باند از جمله جذب انرژی و فرکانس تشدید گوش میانی، کامپلاینس، حجم کانال گوش خارجی، گرادیان و فشار قله تمپانوگرام در فرکانس‌های ۲۲۶، ۶۷۸، ۸۰۰ و ۱۰۰۰ هرتز نشان داد. این یافته‌ها بر اهمیت استفاده از هنجارهای مخصوص به هر نژاد در ارزیابی‌های بالینی تأکید دارد. **نتیجه‌گیری:** مطالعه حاضر مقادیر هنجار اندازه‌گیری WBTP را ارائه می‌کند که می‌تواند به سودمندی بالینی این روش کمک کند. همچنین این یافته‌ها می‌تواند به تشخیص انواع اختلالات گوش میانی و نظارت بر پیشرفت درمان کمک کند.

تاریخ دریافت: ۲۹ تیر ۱۴۰۳
تاریخ پذیرش: ۲۸ مرداد ۱۴۰۳
تاریخ انتشار: ۲۷ شهریور ۱۴۰۳

کلیدواژه‌ها:

تمپانومتري عريض باند،
داده‌های هنجار، گوش
میانی، تمپانومتري،
جمعیت ایرانی

Use your device to scan
and read the article online



Cite this article as Ahadi M, Yazdani N. Establishing Wideband Tympanometry Clinical Normative Data for the Iranian Young Adult Population. Function and Disability Journal. 2024; 7:E40.1. <http://dx.doi.org/10.32598/fdj.7.40.1>

<http://dx.doi.org/10.32598/fdj.7.40.1>

* نویسنده مسئول:

دکتر محسن احدی

نشانی: تهران، دانشگاه علوم پزشکی ایران، دانشکده علوم توانبخشی، مرکز تحقیقات توانبخشی، گروه شنوایی شناسی.

تلفن: ۰۲۲۲۵۰۵۴۱ (۲۱) ۰۹۸

رایانامه: mohsenahadi@gmail.com