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The Effect of Ethnicity on Wideband Absorbance of Neonates with Healthy Middle Ear Functions in Malaysia: A Preliminary Study

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Background and Objectives: Although ethnicity effect on wideband absorbance (WBA) findings was evident for adults, its effect on neonates has not been established yet. This study aimed to investigate the influence of ethnicity on WBA measured at 0 daPa from neonates with healthy middle ear functions. **Subjects and Methods**: Participants were 99 normal, healthy, full-term newborn babies with chronological age between 11 and 128 hours of age (mean=46.73, standard deviation=26.36). A cross-sectional study design was used to measure WBA at 16 one-third octave frequency points from 99 neonates comprising of three ethnic groups: Malays (n=58), Chinese (n=13) and Indians (n=28). A total of 165 ears (83.3%) that passed a battery of tests involving distortion product otoacoustic emissions, 1 kHz tympanometry and acoustic stapedial reflex were further tested using WBA. Moreover, body size measurements were recorded from each participant. **Results**: The Malays and Indians neonates showed almost identical WBA response across the frequency range while the Chinese babies showed lower absorbance values between 1.25 kHz and 5 kHz. However, the differences observed in WBA between the three ethnic groups were not statistically significant (p=0.23). Additionally, there were no statistically significant difference in birth weight, height and head circumference among the three ethnic groups. **Conclusions**: This study showed that Malays, Chinese and Indians neonates were not significantly different in their WBA responses. In conclusion, to apply for the ethnic-specific norms is not warranted when testing neonates from population constitute of these three ethnicities.

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KEY WORDS: Middle ear · Wideband absorbance · Neonates · Ethnicity.

Introduction

Reports from previous studies have suggested the use of high frequency tympanometry (HFT) with a probe tone of 1,000 Hz when testing the middle ear function of neonates [1-4]. However, factors such as variability in tympanometric patterns associated with healthy middle ear and ambiguous classification system to categorize the curves hinder the widespread use of HFT among clinicians [5]. HFT has also poor sensitivity at differentiating normal ears from pathological ears in neonates [6,7]. To overcome such limitations, researchers have turned to an alternative diagnostic tool called wideband absorbance (WBA).

In recent years, the application of WBA in healthy neonates has been extensively studied, and consequently, normative data for this population have been established [8-12]. Taken together, a general pattern of WBA has consistently been observed in most studies, with absorbance being lowest at frequencies below 1,000 Hz and above 4,000 Hz and highest in the frequency region between 1,000 Hz and 4,000 Hz. Besides establishing the patterns, certain demographic factors like gender, ear and ethnicity have been hypothesized to

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influence WBA findings. Among these variables, the effects of gender and ear have been studied more extensively [13-16] while those including data for ethnicity are sparse yet. For instance, Shahnaz and Bork [15] reported significant difference in WBA when measurements were obtained from two ethnic groups of Caucasian and Chinese young adults. Generally, their Caucasian subjects showed significantly higher WBA values at frequencies below 1,500 Hz and lower WBA at frequencies above 3,800 Hz when compared to Chinese participants. Similarly, Beers and her colleagues [13] reported a significant interaction between frequency and ethnicity on WBA values obtained from Caucasian and Chinese school-aged children with Caucasian having lower WBA values over the mid-frequency range compared to Chinese children. Although the exact source of the observed variation in WBA measurements between Caucasian and Chinese is not known, the aforementioned researchers have postulated that body-size differences between these two ethnic groups could be a contributing factor. This assumption was made because both studies did not measure body's weight and height; factors that may differ between ethnic groups and lead to differences in body size between ethnic groups.

To the best of our knowledge, there is only one published study that has examined the effect of ethnicity on ambient WBA in neonates. Aithal, et al. [17] found significant difference in WBA measured at ambient pressure between Aboriginal and non-Aboriginal neonates who passed or failed a screening test battery. They found a significant effect for ethnicity between the two groups who passed the screening test batteries with the Aboriginal group demonstrated significantly lower WBA from 0.4 kHz to 2 kHz than non-Aboriginal babies. Likewise, a comparison between WBA values obtained from 77 ears of non-Aboriginal and 19 ears of Aboriginal neonates who failed the screening tests also showed a significant interaction between ethnicity and frequency, with non-Aboriginal group showing higher absorbance values in comparison with Aboriginal neonates at frequencies between 1.5 kHz and 3 kHz. The authors suggested that the significant in WBA between the two ethnic groups may partially related to the disparities in birth weight; the difference in birth weight between the two ethnic groups nearly approaching the significance levels (p=0.07) with non-Aboriginal neonates have higher birth weight than Australian Aboriginal (i.e., 3.53 kg vs. 3.37 kg, respectively).

Apart from Aithal, et al. [17], there have been no other studies that evaluate the influence of ethnicity on WBA in neonates. Therefore, this study aimed to investigate the effect of ethnicity on WBA measured at 0 daPa in neonates from the three main ethnic groups in Malaysia: Malays, Chinese and Indians. Malaysia is a South-east Asian, middle-income nation. Of a total population of 31.7 million in 2016, the Malays made up 50%, Chinese 23%, Indians 7%, Indigenous people 11% and others 9% [18]. Thus, multi-ethnic Malaysia provides an excellent setting for a study on identifying the role of ethnicity on WBA among this population. Should there be significant differences between ethnicity; the application of one normative data for all ethnic groups is not recommended because the results may lead to erroneous conclusions about the neonates' middle ear status.

Subjects and Methods

Participants

All participating neonates were recruited from the maternity ward of the Kuala Lumpur General Hospital in Kuala Lumpur, Malaysia. Neonates were invited to participate in the study if the following inclusion criteria were met; a) they were born at full term, b) they had no medical complications, c) they had no known risk factors for hearing loss as outlined by the Joint Committee on Infant Hearing (2007) [19], and d) they were not born to mixed-race parents. In addition, they were required to pass the following tests: 1) HFT (1,000 Hz), 2) acoustic stapedial reflex (ASR), and 3) distortion product otoacoustic emissions (DPOAE). A pass in these three tests suggests that the participants have normal middle ear function.

Ninety nine neonates (198 ears), including 43 males and 56 females, participated in this study. Of the 99 neonates, 58 were Malays, 28 were Indians, and 13 were Chinese. However, only 165 ears (82 right and 83 left ears) met all of the above inclusion criteria. These neonates were born full term with a mean gestational age of 38.5 weeks (range=37−41 weeks) and a chronological age (age of the neonate at the time of testing) ranging between 11 and 128 hours [mean=46.7 hours, standard deviation (SD)=26.4]. Table 1 summarizes descriptive statistics for gestational age, chronological age, birth weight, birth height, and head circumference of the participating neonates according to ethnic groups.

Instrumentation

Four tests, namely the HFT, ASR, DPOAE, and WBA were carried out on each neonate using two separate devices. The first device, a Madsen Otoflex 100 diagnostic immittance meter (GN Otometrics, Taastrup, Denmark), was used to perform the HFT and ipsilateral ASR tests.

DPOAE and WBA measures were obtained with the Interacoustics Titan version 1.08.11 (Interacoustics, Middelfart, Denmark). In this study, the Titan device was controlled from a laptop computer via a universal serial bus connection, and

Table 1. Descriptive data of study variables in neonates by ethnicity

Ethnicity	Gestational age (weeks)	Chronological age (hours)	Birth weight (kg)	Birth height/ length (centimeter)	Head circumference (centimeter)
Malay (n=58)					
Mean	38.50	44.12	3.06	47.72	33.51
SD	1.10	27.01	0.42	1.90	1.67
Minimum	37.00	18.00	1.85	42.00	30.50
Maximum	41.00	128.00	4.10	54.00	39.00
Chinese (n=13)					
Mean	38.83	44.77	2.94	47.65	32.67
SD	0.94	24.45	0.24	1.77	1.39
Minimum	37.00	12.00	2.45	44.00	30.00
Maximum	40.00	85.00	3.40	50.00	35.00
Indian (n=28)					
Mean	38.18	53.04	2.86	47.70	32.70
SD	1.09	25.67	0.36	2.15	1.65
Minimum	37.00	11.00	2.25	44.50	30.00
Maximum	40.00	127.00	3.45	52.00	37.50
Malay, chinese and indian (n=99)					
Mean	38.45	46.73	2.99	47.71	33.19
SD	1.09	26.36	0.39	1.94	1.66
Minimum	37.00	11.00	1.85	42.00	30.00
Maximum	41.00	128.00	4.10	54.00	39.00

SD: standard deviation

measurements of WBA and DPOAE were performed using the impedance (IMP440/WBT440) and DPOAE (DP440) modules, respectively. Both devices were calibrated according to manufacturer's instruction prior to data collection.

Procedure

This study was approved by the Universiti Kebangsaan Malaysia Ethical Review Committee (NN-2015-079) and the Medical Research and Ethics Committee of the Ministry of Health Malaysia (NMRR-10-966-7443). Additionally, mothers of the neonates gave written consent before testing.

Testing was performed by an experienced clinical audiologist. All neonates were tested individually, in their bassinets, next to their mother's bed while in a sleeping or calm state. Both ears were tested. The most accessible ear was tested first. Depending on the state of the neonate, HFT, ipsilateral ASR, DPOAE, and WBA tests were performed in no particular order.

Measurements of HFT and ipsilateral ASR began by choosing a suitable ear tip to create an airtight seal. Once the seal was obtained, a probe tone of 1,000 Hz at an intensity level of 75 dB SPL was presented to the neonate's ear to generate a tympanogram. The pressure in the ear canal was varied from a positive to negative direction (+200 daPa to -400 daPa) at a rate of 400 daPa/s. The pass criterion for HFT was a single positively peaked tympanogram with static admittance (Y) of at least 0.02 mmho [20]. Immediately following HFT, the ipsilateral ASR responses was recorded using a broadband noise stimulus. Initially, the stimulus level was presented for 1 sec at an intensity level starting at 50 dB HL using an auto threshold search mode. A change in admittance in either upward or downward direction exceeding 0.04 mmho was considered as an ASR response. A neonate was considered to have passed this test if the ASR responses fell between 50 dB HL and 80 dB HL [20].

To start DPOAE and WBA measurements, an appropriate sized ear tip was placed on the probe assembly to achieve hermetic seal. DPOAE recordings were elicited using the primary stimulus f1 and f2 with a fixed ratio at 1.22. The stimulus levels of the primary frequencies (L1 and L2) were held constant at 65 dB SPL for LI and 55 dB SPL for L2. The DPOAE amplitude and the noise floor were recorded at 2, 3, 4, and 6 kHz. DPOAE responses were considered a pass when the signal-to-noise ratio was greater or equal to 6 dB SPL in at least three out of four measured frequencies [21] and the minimum absolute DPOAE level were at least -6 dB SPL [22].

Titan IMP440/WBT440 module was used to measure WBA using a click stimulus presented at 96 dB peSPL (≈61 dB nHL) at a click rate of 21.5 Hz [23] while the pressure was swept from +200 to -300 daPa at a medium rate of approximately 200 daPa/s. The device automatically generated a three-dimensional plot of WBA, which ranges from 0 to 1, as a function of frequency from 226 Hz to 8,000 Hz and ear canal pressure. The device also displayed a plot of WBA at 0 daPa as a function of frequency which is extrapolated from the three-dimensional plot. The data acquisition was very quick and each WBA measurement took 10−15 seconds to complete.

Statistical analysis

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) software version 23 (IBM Corp., Armonk, NY, USA). Boxplot and normal quantile-quantile plot were used to examine the normality of WBA across the 16 one-third octave frequencies. The WBA data was normally distributed across the 16 frequencies, therefore, parametric tests were used to analyses the data. Besides descriptive statistics, a separate one-way analysis of variance (ANOVA) between subjects was conducted on chronological age, birth weight, height and head circumference to compare between Malay, Indian and Chinese neonates. A mixed model-ANOVA was used to investigate the effect of ethnicity, gender and ear on absorbance. The Greenhouse-Geisser approach [24] was used to compensate for the violation of compound symmetry and sphericity. Additionally, a Pearson product-moment correlation coefficient was used to examine the relationship between the independent factors (birth weight, birth height, head circumference, gestational age and chronological age) and WBA responses at the 16 one-third octave frequencies. An alpha level of 0.05 was used for all analysis.

Results

Fig. 1 displays the mean absorbance at 0 daPa for the three ethnic groups (i.e., Malay, Chinese, and Indian) from 250 Hz to 8,000 Hz. The absorbance ranges from 0, where all energy is reflected by the middle ear, to 1, where all the energy is absorbed by the middle ear. Generally, the mean absorbance results for all groups show a similar characteristic trend with two minima and two maxima. In specific, all groups attained their two minima at 500 Hz and 4,000 Hz, respectively. Moreover, there were relatively large differences in the mean WBA results at 4,000 Hz among the three groups with Chinese having the lowest value (0.29) in comparison to the Malays and Indians (around 0.40). It was also observed in Fig. 1 that the two maxima for all groups occurred at the same frequencies (approximately at 125 Hz and 6,300 Hz). The plot of mean absorbance of the three ethnic groups also shows that Chinese group had lower absorbance values between 1.25 kHz and 5 kHz. The absorbance values for Malay and Indian groups were almost identical across the frequency range (250−8,000 Hz). The differences in mean absorbance between the Chinese and the other two groups reach its greatest at 4 kHz (about 0.11).

A separate one-way ANOVA between subjects was conducted on chronological age, birth weight, height, and head circumference to investigate whether significant differences exist among Malay, Indian and Chinese neonates. There was no significant difference among the three ethnic groups in gestational and chronological age {[F (2, 95)=1.71, *p*=0.186] and [F (2, 96)=1.12, *p*=0.329], respectively}, birth weight [F

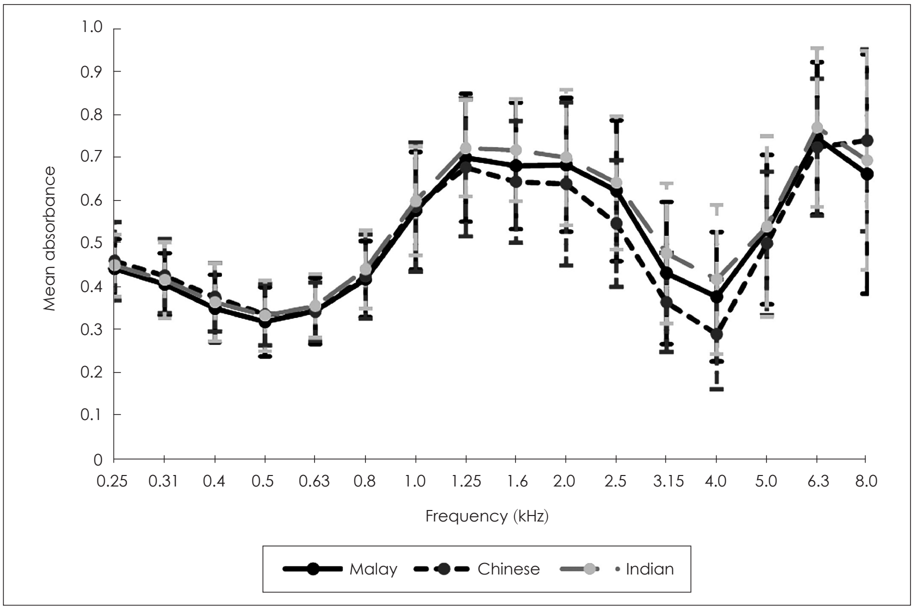

Fig. 1. Mean wideband absorbance at 0 daPa across the 16 frequencies for the three ethnic groups: Malay, Chinese, and Indian. Vertical bars denote mean ± 1 standard deviation.

(2, 96)=2.71, *p*=0.072], birth height [F (2, 96)=0.01, *p*=0.993], and head circumference [F (2, 96)=2.89, *p*=0.060].

A mixed-model ANOVA was applied to the WBA data with frequency (16 frequencies) as within subject factors, and ear (right vs. left), gender (male vs. female) and ethnicity (Malay vs. Chinese vs. Indian) as between subject factors. The main effect of frequency was significant [F (4.32, 661.58)=135.92, *p*<0.001]. However, the main effect of ethnicity was insignificant [F (2, 153)=1.48, *p*=0.230]. Similarly, the effect of gender and ear were insignificant {[F (1, 153)=0.06, *p*=0.450] and [F (1, 153)=226, *p*=0.135], respectively}. All interaction effects were also insignificant. The results of ANOVA are summarized in Table 2.

A post hoc analysis with Bonferroni correction was performed to investigate the significant frequency effect on WBA measured at 0 daPa. Table 3 shows the paired comparisons that yield a significant difference with *p*<0.05. WBA at frequencies 0.25 kHz and 0.31 kHz differed significantly with WBA at 0.4−0.63 kHz, 1−2.5 kHz, and 4−8 kHz. Moreover, WBA was significantly different between the 0.4−0.8 kHz and 1−8 kHz regions and between the 1.25−2 kHz−2.5−5 kHz regions. In contrast, the were no significant differences in

Table 2. A summary of analysis of variance results for wideband absorbance obtained from all ears (n=165)

	df	F-value	*p*-value	Partial eta squared	Observed power
Frequency	4.32	135.92	0.00	0.47	1.00
Race	2.00	1.48	0.23*	0.02	0.31
Gender	1.00	0.57	0.45	0.00	0.12
Ear	1.00	2.26	0.14	0.01	0.32
Frequency × race	8.65	1.07	0.38	0.01	0.53
Frequency × gender	4.32	2.03	0.08	0.01	0.63
Frequency × ear	4.32	1.00	0.41	0.01	0.33
Frequency × race × gender	8.65	1.04	0.41	0.01	0.51
Frequency × race × ear	8.65	0.80	0.62	0.01	0.39
Frequency × gender × ear	4.32	0.35	0.86	0.00	0.13
Frequency × race × gender × ear	8.65	0.77	0.64	0.01	0.38
Race × gender	2.00	0.53	0.59	0.01	0.14
Race × ear	2.00	0.84	0.44	0.01	0.19
Gender × ear	1.00	0.70	0.41	0.00	0.13
Race × gender × ear	2.00	0.60	0.55	0.01	0.15

*significant difference at an alpha level of <0.05. df: degree of freedom

Table 3. Paired comparisons that showed a significant difference of wideband absorbance at 0 daPa (Bonferroni correction was applied)

Frequency (kHz)	Frequency (kHz)														
	0.31	0.4	0.5	0.63	0.8	1	1.25	1.6	2	2.5	3.15	4	5	6.3	8
0.25	0.000	0.000	0.000	0.000	ns	0.000	0.000	0.000	0.000	0.000	ns	0.000	0.006	0.000	0.000
0.31		0.004	0.005	0.007	0.010	0.014	0.014	0.014	0.016	0.016	0.016	0.015	0.016	0.017	0.028
0.40			0.003	0.005	0.009	0.014	0.014	0.014	0.016	0.017	0.016	0.015	0.016	0.017	0.028
0.50				0.003	0.008	0.013	0.013	0.014	0.016	0.017	0.017	0.016	0.017	0.017	0.028
0.63					0.005	0.011	0.012	0.013	0.017	0.018	0.017	0.016	0.017	0.017	0.027
0.80						0.000	0.000	0.000	0.000	0.000	ns	0.004	0.000	0.000	0.000
1.00							0.000	0.000	ns	ns	0.000	0.000	ns	0.000	ns
1.25								ns	ns	0.004	0.000	0.000	0.000	ns	ns
1.60									ns	0.001	0.000	0.000	0.000	ns	ns
2.00										0.000	0.000	0.000	0.000	ns	ns
2.50											0.000	0.000	0.004	0.000	0.028
3.15												0.000	0.000	0.000	0.000
4.00													0.000	0.000	0.000
5.00														0.000	0.000
6.30															ns

ns: not significant at an alpha level of <0.05

WBA between 2 kHz and the frequencies from 1 kHz to 1.6 kHz, and between frequencies 1.25−2 kHz and 6.3−8 kHz.

In addition, the correlations between the five independent factors (birth weight, birth height, head circumference, gestational age, and chronological age) and WBA responses at the 16 one-third octave frequencies were examined using Pearson product-moment correlation coefficient. Overall, there were no statistically significant correlations between WBA and birth weight, height, and head circumference at any of the frequencies. However, a weak positive correlation was observed between WBA and chronological age at 1.6, 2.0, 2.5, 3.15, and 4 kHz [r (165)=0.23, *p*=0.003, r (165)=0.34, *p*<0.001, r (165)=0.36, *p*<0.001, r (165)=0.32, *p*<0.001, and r (165)= 0.20, *p*=0.010, respectively].

Discussion

The present study aimed to investigate the influence of ethnicity on WBA measured at 0 daPa from the three largest ethnic groups of healthy neonates born in Kuala Lumpur, Malaysia; Malays, Chinese, and Indians. The results revealed no statistically significant effect of ethnicity on WBA across the frequency range; that is, Malay neonates produced WBA responses that are similar to Indians and Chinese.

Although statistical analysis showed no significant differences in WBA between the three ethnic groups, it was demonstrated in from Fig. 1 that Chinese babies showed lower mean absorbance values between 1.25 kHz and 5 kHz than Malay and Indian groups. Given such a small sample size in the present study, effect sizes (Hedges' g) at each one-third octave frequency was calculated using the mean and SD of the absorbance of the three ethnic groups (Table 4). As shown in Table 4, the effect sizes at two of the one-third octave bands (i.e., 3,150 Hz and 4,000 Hz) are considered relatively large, with Hedges' g values close to 0.8 [25,26]. Fig. 2 illustrates box-and-whisker plots for WBA obtained at these high-frequency bands; the box-and whisker plots represent WBA data from Malays, Chinese and Indians neonates. The box depicts the 25th and 75th percentiles of WBA, respectively; the line in the middle of the box represents the median, and the lower and upper whiskers represent the 10th and 90th percentiles, respectively. As seen in Fig. 2, WBA data from Chinese neonates overlay the range from the ears of Malays and Indians

Table 4. Effect sizes for wideband absorbance at 0 daPa between Malay, Chinese, Indian, and Chinese across the 16 one-third octave frequencies

Frequency (kHz)	Effect size between Malay and Chinese	Effect size between Indian and Chinese
0.25	0.24	0.13
0.31	0.27	0.11
0.40	0.34	0.14
0.50	0.21	0.03
0.63	0.02	0.19
0.80	0.07	0.18
1.00	0.06	0.10
1.25	0.15	0.35
1.60	0.26	0.59
2.00	0.28	0.37
2.50	0.47	0.62
3.15	0.43	0.76
4.00	0.59	0.79
5.00	0.19	0.20
6.30	0.12	0.26
0.80	0.29	0.21

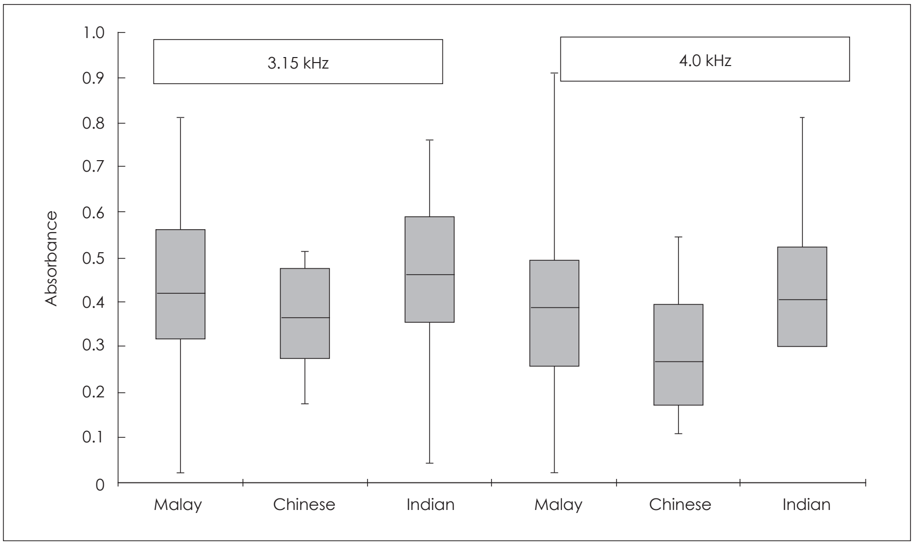

Fig. 2. Box-and-whisker plots for WBA obtained at 3.15 and 4 kHz; the box-and whisker plots represent WBA data from Malays, Chinese, and Indians neonates. WBA: wideband absorbance.

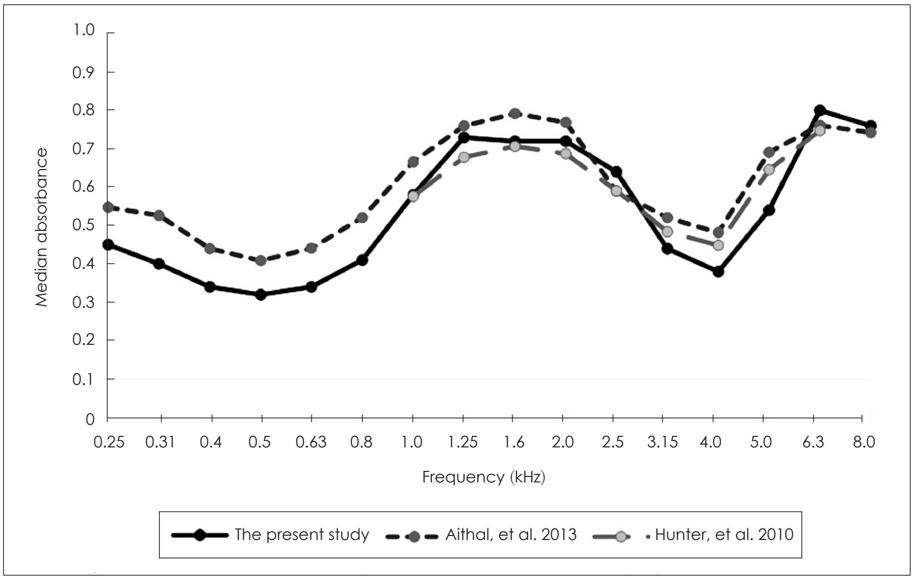

Fig. 3. Median WBA at 0 daPa across frequencies for the present study and median WBA at ambient pressure from Aithal, et al. (2013) and Hunter, et al. (2010) studies. Adapted from Aithal, et al. Int J Pediatr Otorhinolaryngol 2013;77:29-35 [8]. Adapted from Hunter, et al. Ear Hear 2010;31:599-610 [6]. WBA: wideband absorbance.

babies. These results verify that WBA data obtained for all neonates, indeed, are similar.

Despite the evidence that body-size differences could be a contributing factor impacting WBA findings among ethnicities, a direct measure of this parameter has not performed in any of the earlier studies (i.e., 13 and 15) except in Aithal, et al. [17]. In specific, Aithal and her colleagues measured the birth weight of Caucasian and Australian Aboriginal neonates (3.53 kg vs. 3.37 kg, respectively) which revealed no significant difference between the two groups. However, they suggested that the birth weight could partially contribute to the observed absorbance differences because the *p*-value obtained in their study (p=0.07) approaches the level of significance. Besides birth weight, other parameters that may influence WBA findings are participant's height/length and head circumference. These factors were explored in the present study and it was found that neonates from the three largest ethnics groups in Malaysia did not differ significantly in terms of their birth weight, height/length, and head circumference. Therefore, this finding could partially explain why the Malays, Chinese and Indians newborn infants showed no significant differences on WBA measures.

To our knowledge, the present study was the first study describing WBA findings from Malay, Chinese and Indian neonates. A comparison between the median WBA of the present study with two previous studies [6,8] were displayed in Fig. 3. As shown in Fig. 3, the median absorbance in the present study between 0.25 kHz to 1.25 kHz were lower than that observed in the Aithal, et al. [8] study. However, the opposite was seen at 3.15−5 kHz, with the median absorbance was lower in the Aithal, et al. [8] study compared with the present study. The fact that the mean birth weight of the neonates in the present study was significantly lower than that of the Aithal, et al. [8] study (2.99 kg vs. 3.53 kg) may contribute to the differences observed in WBA results between the two studies.

Fig. 3 also shows that the median WBA of the present study was lower at 3.15−5 kHz than that observed in Hunter, et al. [6] study which could also be, in part, attributed to the differences in subjects' birth weight and head circumference between the two studies. In particular, the mean birth weight and the head circumference of the neonates participated in Hunter, et al. [6] study were higher than those of the present study (3.23 kg vs. 2.99 kg) and (0.33 m vs. 0.35 m), respectively. It should be noted that the comparison of median WBA between the two studies at low frequencies were not possible as Hunter, et al. [6] did not report the results of WBA for frequencies below 1 kHz.

The relationships between the independent factors (i.e., birth weight, birth height, head circumference, gestational age, and chronological age) and WBA responses at the 16 one-third octave frequencies were investigated to explore the presence of any significant correlation that could indicate a possible contribution of these independent factors on WBA measures. The results of correlation analysis showed no systematic significant correlation occurred between absorbance values across frequencies and the five independent factors. Furthermore, all the observed relationships were weak in degree. Nevertheless, WBA at four consecutive one-third octave frequencies (1.6, 2.0, 2.5, and 3.15 kHz) showed a positive correlation with chronological age of the neonates. In other word, as the newborn infant grows few days, the absorbance at these frequencies increases. This finding is in agreement with earlier studies, which reported an increase in sound conduction in the first few days of life [7,10] due to the clearance of debris and amniotic fluid from the ear. This study showed no difference in absorbance due to infants' body size, which is similar to the finding of Hunter, et al. [6]. The fact that the present study observed no systematic positive correlation between WBA and body size indices (birth weight, height, and head circumference) could indicate a lack of contribution of body size on the differences in WBA among ethnicity in young infants.

In conclusion, the fact that the present study showed no significant differences in WBA measured at 0 daPa between the three ethnic groups: Malays, Chinese and Indians may indicate that using ethnic-specific normative data is not warranted for any of the three ethnic groups. Therefore, findings from the present study can only be generalized when testing neonates from these three main ethnic groups in Malaysia. The application of the present findings in other ethnic groups in Malaysia such as indigenous and non-citizens should be interpreted with care.

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Conflicts of interest

The authors have no financial conflicts of interest.

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