Short Article

Real-ear Unaided Gain in Wrestlers with Unilateral Cauliflower Ear

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Highlights

- The REUG is used in people with unilateral cauliflower ear
- There was significant difference for REUG among cauliflower and normal ears
- REAG can be a reliable hearing aid verification method for cauliflower ears

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ABSTRACT

Background and Aim: Real-Ear Unaided Gain(REUG) can reveal the outer-ear resonance which reflects the effects of body and ear factors. Deformity in the outer ear may change the real-ear unaided responses. Cauliflower ear is a common ear deformity in wrestlers. Therefore, the use of required hearing aid gain in people with hearing loss for people with cauliflower ears may be inaccurate and causes dissatisfaction. This study aimed to compare the REUG of normal and cauliflower ear in wrestlers to investigate the frequencies at which the gain may be inaccurate.

Methods: Ten male wrestlers with the age ranged from 21 to 31 years participated in this study. The study had within-subject design and only one group. The REUGs was recorded for both ears (normal and cauliflower ears) and the results analyzed.

Results: The mean of REUG values were significantly different between the deformed and normal ears. There were two distinct peaks in the REUG curve of the deformed ear, while there was a single peak in that of the normal ear.

Conclusion: The differences in the REUG at 2–6 kHz between the deformed and normal ears should be adjusted to reach the optimal hearing level for a hearing aid user with cauliflower ear.

Keywords: Cauliflower ear; real ear unaided gain; hearing aid verification; target gain

Introduction

The cauliflower ear or wrestlers' ear is a deformity caused by blunt trauma to the auricle. It is common in sports such as wrestling, judo, and rugby [1], mostly in wrestling which is a popular sport in Asia [2]. In 1989, the cauliflower ear was reported in 39% of wrestlers in USA [3]. In Iran, a study showed that 44% of wrestlers had cauliflower ears [2]. The blunt trauma to the auricle results in the formation of hematoma between the cartilage and the perichondrium. This tissue may be thickened and cause cauliflower ear [4-8]. In addition to the aesthetic problems, this condition may cause hearing loss and make the ear canal susceptible to the formation of impacted cerumen [9].

The ear canal in human'sacts as a physical closed tubes which have resonant frequencies (peaks) at the natural frequency responses of the ear. In addition, due to the bulges in the auricle and ear canals and according to the law of closed pipes in physics, there may be other resonance (peaks) and anti-resonance (troughs) in the frequency response of the ear canal [10]. The frequency response of the ear canal is measured by a probe-tube microphone. The probe-tube tip is placed inside the ear canal close to the Tympanic Membrane (TM), while the microphone is outside the ear canal. This kind of measurement is called Real-Ear Measurement (REM). The frequency curve measured by REM method is called Real-ear Unaided Response (REUR) when the probe microphone is not in the ear, and it is called Real-ear Aided Response (REAR) when the probe microphone is in the ear. Sometimes, the only peak of the REUR is called Real-Ear Unaided Gain (REUG). A single-peak resonance occurs at a frequency of 2–6 kHz with 12–20 dB SPL. If the shape or size of the auricle or ear canal changes, it may affect REUG or REUR [11].

A person with hearing loss may need hearing aids. In the fitting of a hearing aid, an amplification or gain (expressed in dB SPL) is added to the incoming sounds at each frequency according to the degree of hearing loss (target gain). However, the characteristics of ear canals affect the amount of the gain that a hearing aid should produce. Since these responses are important factors in fitting hearing aids, the differences between normal and cauliflower ears should be compensated for in order to provide enough gain for a person with both hearing loss and cauliflower ears [12].

Currently, there is no study to show how/how much the REUG is changed due to deformities in the auricle and ear canal. Without this information, the hearing aid fitting software uses the information of people with normal ear which may be different in hearing some speech sounds compared to the ear of a person with a hearing aid. This study aimed to compare the REUG of the cauliflower ear and normal ear in the wrestlers to measure the changes in the frequency responses of the cauliflower ears compared to normal ears. This information may modify the target gain defined by hearing aid fitting formulas.

Methods

Ten male wrestlers with unilateral cauliflower ears (7 in the right ear) participated in this study. Their mean (SD) age was 25.2(3.42) years, ranged from 21 to 31 years. They were selected from among 10 different wrestling clubs, and had a mean wrestling experience of five years, ranged from 3–9 years. The people with bilateral cauliflower ears were not eligible to enter the study, because the aim of the study was to compare the changes between affected ear and normal ears using a within-subject design. Figure 1 shows the ear of a participant with normal ears compared to a participant with cauliflower ear.

None of participants reported any middle ear or TM surgery. The otoscopic examination was performed to confirm that there was no abnormality in the ear canal and impacted cerumen that can prevent the REM. Then, routine middle ear assessments: tympanometry at 226-Hz and acoustic reflex testing (r25c model, Resonance, Italy) and pure-tone test and speech audiometry using an audiometer (r37a model, Resonance, Italy) were administered to confirm that there was no conductive deformity in their ears including their cauliflower ears. Since the possibility of ear canal collapse might be higher in people with cauliflower ears, insert earphone (ER-3A) was used for audiometric assessment.

The REM was conducted in Primus (Auditdata, Denmark). In this method, the REUG was recorded after the stimuli were presented using LS-01B loudspeakers (Auditdata, Denmark) which were set at the ear level and located in 1.5 meters away from each participant at 0 azimuth degrees, since two ears were tested simultaneously. The stimuli were wideband noises with equal acoustic energy (55 dB SPL) at the frequency response of the loudspeaker. The probe tube marker was set at 31 millimeters (recommended for male adults) while its tip was 5 millimeters away from the TM [11]. The proper position of the probe tube was confirmed with an otoscopic examination after its placement in the ear canal. Two recorded responses were averaged for each REM.

Table 1. Audiometric values for cauliflower and normal ears

Subject	Puretone average (dB)	
	Cauliflower ears	Normal ears
1	10	10
2	15	10
3	10	5
4	15	10
5	5	10
6	10	5
7	20	15
8	10	10
9	10	15
10	10	10
Mean(SD)	10.70(4.10)	10.00(3.33)

All assessments were administered in an acoustic booth. There were 28 frequency points in each response curve. Therefore, the differences for 28 paired frequencies were calculated between the cauliflower and normal ears. The gathered data were entered into SPSS version 17. Since the data had normal distribution based on the results of Kolmogorov-Smirnov test, an adjusted paired t-test was used for assessing the difference in the REUG values of the cauliflower and normal ears. The significance level was set at 0.001 (0.05 divided by 28) to compensate for the type I error according to the Bonferroni's correction method.

Results

The mean and SD of hearing thresholds was 10.5(5.1). All participants had normal tympanogram and acoustic reflexes. Tables 1 and 2 present the pure-tone test means and tympanometric information of the participants. The statistical analyses reached significance levels at 871, 2000, 2639, 3031, 3482, 4000, 5278, 6063 and 6964 Hz. The statistical value (confidence interval=CI) are summarized in Table 3. The maximum REUG was 16.9 at 2639 Hz in the normal ear. As shown in Figure 2, in the cauliflower ear, there were two peaks in the mean REUG curve, one at 2639 Hz with 14.9 dB and other at 5278 Hz with 10.9 dB SPL.

Figure 1. Normal (A) vs. Cauliflower ear (B) in one of the participants

Table 2. Tympanometry values for cauliflower and normal ears

Subject	Cauliflower ears			Normal ears		
	Vec	SC	TPP	Vec	SC	TPP
1	0.62	0.46	–32	0.69	0.65	–36
2	0.92	0.51	6	0.91	0.61	–12
3	0.83	0.40	–25	0.84	0.50	–13
4	1.16	0.87	12	1.19	1.01	–23
5	0.54	0.51	–7	0.61	0.55	–10
6	0.62	0.50	–21	0.70	0.71	–11
7	0.89	0.54	–9	0.79	0.65	0
8	0.50	0.46	–25	0.39	0.73	–36
9	0.86	0.65	–20	1.12	0.69	–18
10	0.62	0.48	–26	0.61	0.51	-24
Mean(SD)	0.75(0.2)	0.53(0.13)	–14(4.04)	0.78(0.24)	0.66(0.14)	–18(7.58)

Vec; ear canal volume (cc or ml), SC; static compliance (mmho), TPP; Tympanometry peak pressure

Discussion

Hearing aid fitting and its verification have always been a challenge. This study compared the REUG between normal and cauliflower ears in wrestlers with unilateral cauliflower ear. For the verification, it is possible to use either Real-Ear Aided Gain (REAG) or Real-ear Insertion Gain (REIG) [13]. If the cases' REUG is close to the REUG offered by the hearing aid fitting software, there may not be a problem. However, when these two are significantly different, the use of REUG is not recommended. These significant differences occur in people with mastoidectomy (with a REUG peak below 2 kHz) and TM perforation (with two distinct REUR peaks). In these cases, the REAG is preferred over REIG since the differences caused by the deformity in the auricle and ear canal are compensated for in the REAG measurements [11, 12, 14, 15].

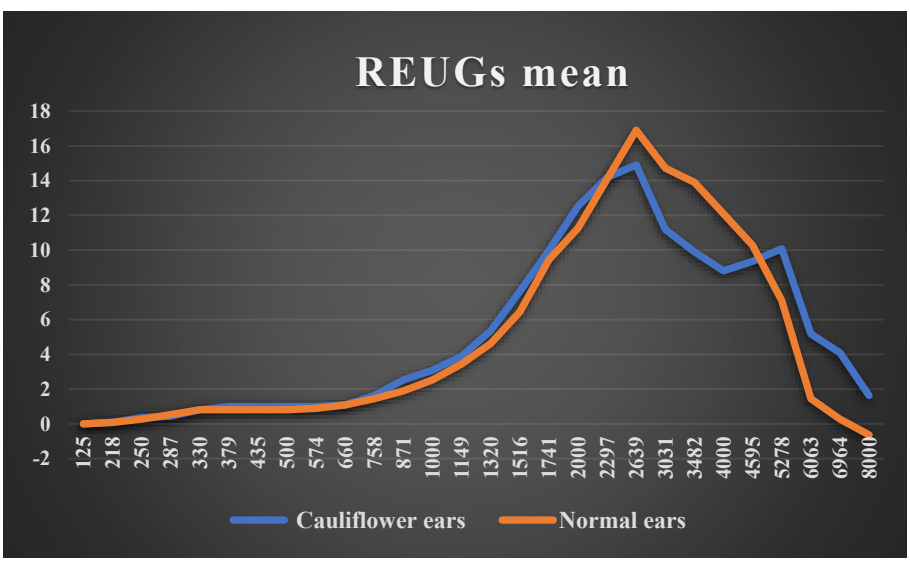

Figure 2. Mean real ear unaided gain values for normal and cauliflower ears. REUGs: real ear unaided gain

Table 3. Statistical value (confidence interval) for different measurement frequencies

99.85% confidence interval		Frequency (Hz)
Upper	Lower	
0.61	–0.79	250
0.79	–0.61	287
0.34	–0.70	379
0.34	–0.70	435
0.34	–0.70	500
0.30	–0.48	574
0.58	–0.58	660
0.60	–0.96	758
0.02	–1.29	871
0.35	–1.44	1000
0.89	–1.80	1149
1.30	–2.75	1320
0.64	–3.00	1510
1.23	–2.33	1741
0.28	–2.80	2000
1.27	–1.45	2297
4.25	–0.25	2639
6.36	0.72	3031
6.60	1.39	3482
5.61	0.93	4000
2.88	–1.06	4595
0.68	–6.68	5278
1.36	–8.81	6063
0.25	–7.89	6964
1.27	–5.82	8000

In this study, the values of gain provided by the ear canal were measured and compared between two ears at 28 frequencies. At the frequency range of 2–6 kHz, there were significant differences. The amplified frequencies were broad with two peaks in the REUG of the cauliflower ears. In a study by Shaw, the effects of the body, ear pinna, and ear canals on the sound pressure impinging on TM were evaluated. The physical aspects of these factors determined the sound pressure. The most influential effects were observed at a range of 1–5 kHz with a peak at 2.5 kHz [16]. Our study showed that at high frequencies, REUGs were significantly different between the two ears. These differences were attributed to asymmetric dips and troughs of the two ears despite the fact that there was no deformity in the concha and outer ear of the two ears.

The deformity in the auricle can affect the REUG and subsequently the target gain calculated by hearing aid fitting formulas. The discrepancy between target gain and required gain in the deformed ears necessitates the corrections and modifications mostly at high frequencies [12]. If these corrections are not made, hearing would be less than enough at some frequencies (first peak region) or the possibility of feedback and hearing loss might increase at other frequencies (second peak region) [17]. The difference observed in REUGs between the normal and cauliflower ears in this study can be considered for reaching the proper gain for people with cauliflower ear. Moreover, since extra high-frequency gain may cause speech sound sharp and be annoying, it may cause improper sound quality which should be compensated for [18]. Therefore, it is recommended that hearing aids for people with unilateral cauliflower ear should be fitted separately for each ear. One of the required factors for the calculation of Coupler Response for Flat Insertion Gain (CORFIG) is the REUG. Therefore, if each person's CORFIG be used, the calculation of CORFIG becomes realistic and can better represent the real hearing conditions. The presence of an extra peak in the REUR can cause inaccuracies in hearing aid coupler measurement [11]. This should also be considered in the verification process of hearing aids. Finally, a further similar study is recommended by assessing the effect of sound quality and fine-tuning of hearing aids in hearing aid users with deformed ears.

Conclusion

Cauliflower ear can significantly change the amount of real-ear unaided gain required for people in a frequency range of 2–6 kHz. If these changes are not taken into account, it creates dissatisfaction with using hearing aids. Therefore, it is recommended that real-ear aided gain should be used for the verification of hearing aids in people with cauliflower ear.

Ethical Considerations

Compliance with ethical guidelines

The whole experiment was done according to Helsinki and Tokyo ethical protocols for testing human participants

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Authors' contributions

KPY: Study concept, design and acquisition of data, interpretation the result; MM: Study design, supervision, acquisition of data, interpretation the result, data analysis.

Conflict of interest

There was no conflict of interest for this study.

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