Short Article

Real-ear Unaided Gain in Wrestlers with Unilateral Cauliflower Ear

Kamal Pahlavan Yali, Mohammad Maarefvand*

Department of Audiology, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran

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Highlights

- The REUG curve pattern in cauliflower ears was different from the normal ears
- Cauliflower's REUG was a curve with two distinct peaks

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*** Corresponding Author:**
Department of Audiology, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran.
Maarefvandm@gmail.com

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. 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 was seen.

Keywords: Cauliflower ear; real ear unaided gain; probe microphone measurement; ear canal resonance

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's acts 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 probe microphone measurement. The frequency curve measured by REM method is called real-ear unaided response (REUR) when hearing aids are not worn on the ear and real-ear aided response (REAR) when hearing aids are worn on the ear. When only gain of the outer ear is shown as a function of frequency, the curve is called Real-ear unaided gain (REUG) which is the REUR minus input sounds. The maximum gain or resonance of the outer ear occurs at the frequency range of 2 to 6 kHz with the intensity level of 12 to 20 dB SPL. If the shape or size of the auricle or ear canal changes, it may affect REUG [11]. Previous studies have shown that torso, neck, head and different parts of the outer ear (e.g., dips and ridges of pinna, concha, and external canal) influence free-field-to-eardrum transformation or REUG. Among those parts, external canal (with resonant frequency around 2500 Hz) and concha (with resonant frequency above 5000 Hz) have pronounced influence on REUG [12].

Currently, there is no study to show how/how much the REUG is changed due to deformities in the auricle especially concha. 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.

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 the same participant with cauliflower ear.

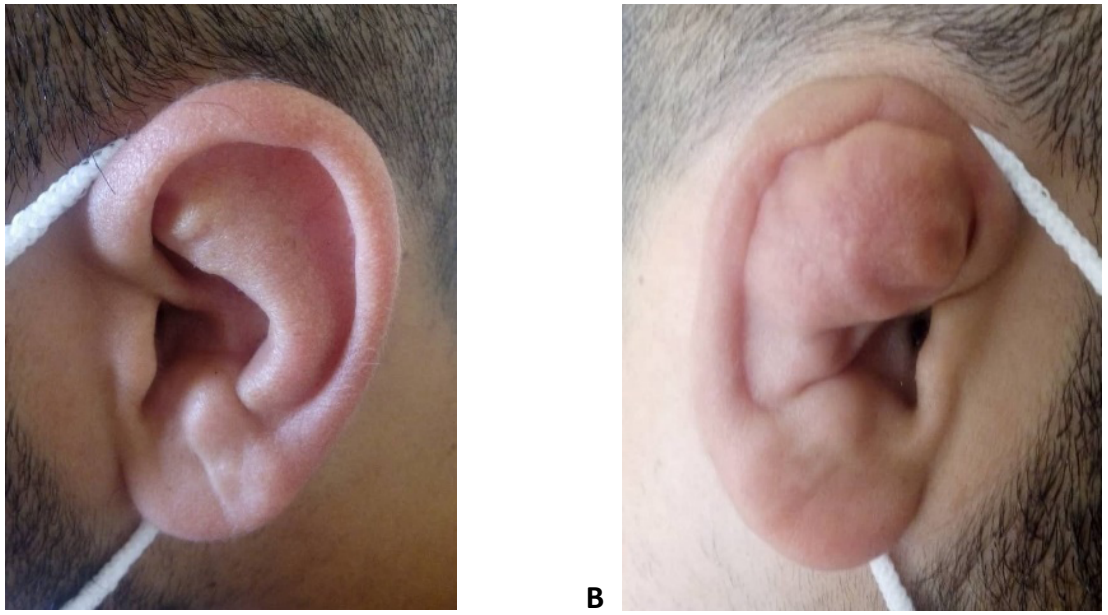

Figure 1. Normal (A) vs. Cauliflower ear (B) in one of the participants

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 probe microphone measurements. The measurement was conducted with Primus (Auditdata, Denmark). In this testing, 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 90 centimeters away from each participant at 0 azimuth degrees, since two ears were tested simultaneously. Before testing, microphone calibration was conducted at the ear level and similar distance from loudspeaker. The stimuli were wideband noises with equal acoustic energy (55 dB SPL) at the frequency response of the loudspeaker. All assessments were administered in an acoustic booth. The probe tube marker was set at 31 millimeters (recommended for male adults) while its tip was 5 millimeters away from the TM [11]. This approach was followed by 6-kHz notch approach in which 6-kHz gain was not lower than 0 dB. 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 REUG responses. 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 maximum REUG was 16.9 at 2639 Hz in the normal ear. As shown in Figure 2 and 3, in the cauliflower ears, 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.

Table 1. Audiometric values for cauliflower and normal ears

Subject	Pure tone 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)

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

This study compared the REUG between normal and cauliflower ears in wrestlers with unilateral cauliflower ear.

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,

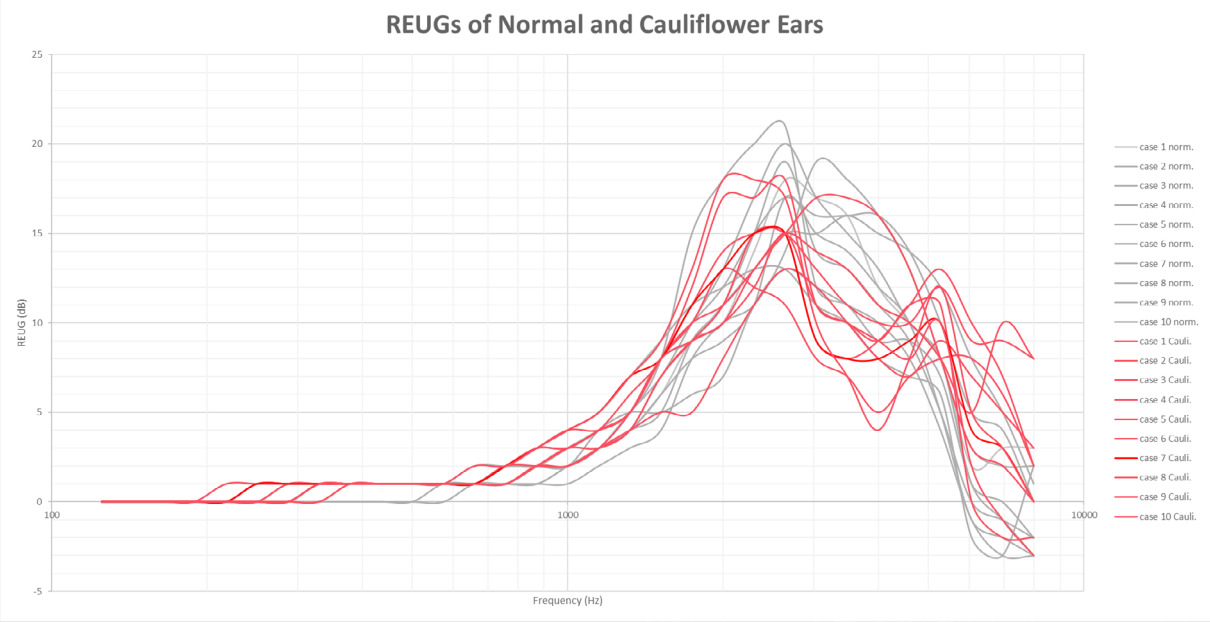

Figure 2. Real ear unaided gains of normal and cauliflower ears among participants. REUGs; real ear unaided gains

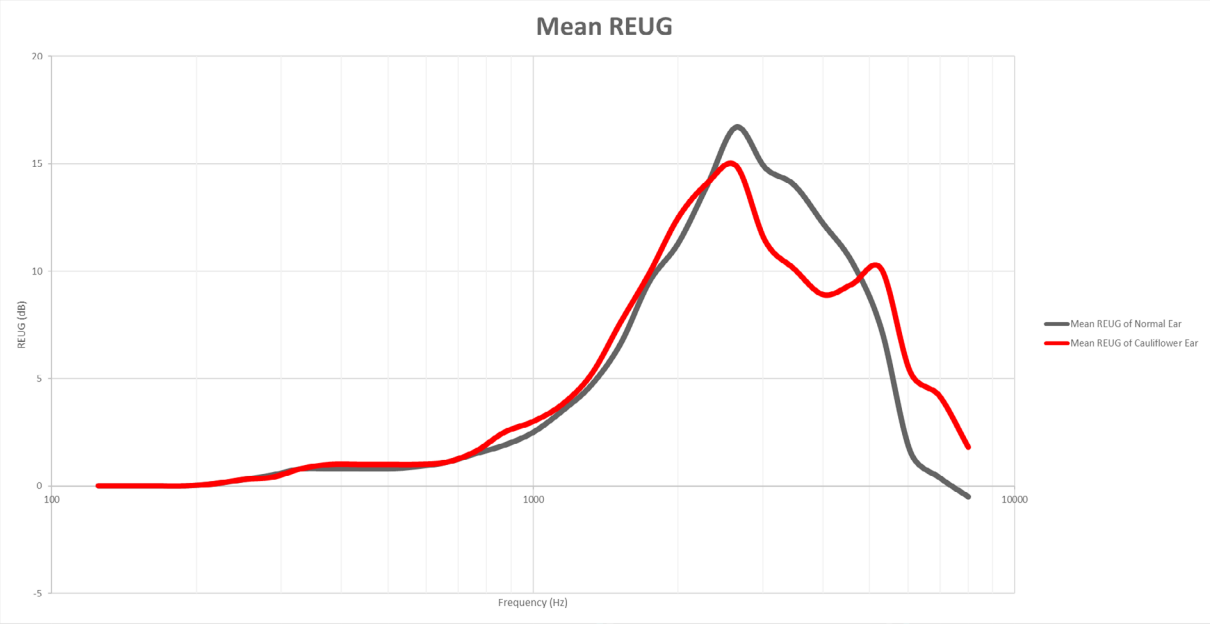

Figure 3. Mean real ear unaided gain values for normal and cauliflower ears. REUGs; real ear unaided gains

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 [12].

The participant of this study had intact external canal and therefore changes in the free-field-to-eardrum transformation could be due to changes in either concha or dips and ridges in pinna. Shaw's study showed pinna had little effect on the transformation. Therefore, the changes observed in high-frequency region might be due to changes in concha rather than pinna. This study assessed the effects of changes in concha on sound transmission which was not assessed before [12]. 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 ear canal and cavum concha of the two ears.

Conclusion

Cauliflower ear can significantly change the real-ear unaided gain required for people with deformities of ear pinna especially auricle (wrestler's ears) in a frequency range of 2–6 kHz.

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

KP: 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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