Association Between Hearing Loss And Cauliflower Ear in Wrestlers, a Case Control Study Employing Hearing Tests

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1. Background

In some sports, such as boxing, rugby, judo and wrestling, a typical deformity of external ear identified as cauliflower ear has been reported (1). Cauliflower ear can be observed widely among wrestlers in some regions such as Asian countries (2).

The major tissue in the texture of pinna is cartilage covered by perichondrium, subcutaneous tissue and skin. Direct blunt trauma or continuous abrasion of the pinna might bring about accumulation of blood and serum in the space between perichondrium and cartilage (3-6); this hematoma might lead to cartilage necrosis through reduction of blood flow into the tissue (7). Cartilage necrosis and fibronecartilage formation in the area results in deformity of the pinna and may result in the loss of cartilaginous support for the shape of the pinna resulting in a “cauliflower ear” or “wrestler’s ear” deformity.

In the United States, it was reported that 39% of collegiate wrestlers had cauliflower ear in 1989 (8). According to the rules of NCCA, employing ear protector devices is mandatory for all wrestlers in both training sessions and competitions (9). However, according to the international wrestling regulations, ear gears are not obligatory for wrestlers except for cadet and junior female wrestlers. It is reported that using ear protectors may be followed by relative reduction of sport injuries of the ear (8).

Wrestling has been a symbol of power and virility for the people in a number of countries. Cauliflower ear is recognized as a “badge of courage” in these regions. Therefore, wrestlers refuse to treat their ear hematoma in order to intentionally develop a cauliflower ear (10). As an example Iranian wrestlers do not employ any kind of ear protection; in addition, most of Iranian wrestlers avoid treatment of
their ear injuries because they believe that cauliflower ear can be considered a symbol of honor for wrestlers (2).

In the literature, cosmetic problems including protrusion and distortion of the ear have been reported as the major direct complication of cauliflower ear in wrestlers (11). In addition, it has been reported that in cases which deformity of the ears continue to the external canal of the ear, it could lead to the obstruction of the external canal (12), and hearing loss would be expected. Deformity of the external canal of the ear might also lead to irregularity in normal wax expelling and thereby increase the rate of ear infections (13).

A previous survey which employed a questionnaire based interview, showed that 44% of wrestlers in Tehran have cauliflower ear. Of the wrestlers with cauliflower ear, 11.5% (95% CI: 6.9% to 16.2%) reported that they feel hearing loss, while only 1.8% (95% CI: 0.1% to 3.5%) of wrestlers without cauliflower ear reported hearing loss. This study was a cross sectional survey on different wrestling clubs in Tehran and no audometric test was performed to evaluate the intensity of hearing loss in wrestlers (2).

2. Objectives

Anecdotal data shows that some wrestlers and their coaches believe that cauliflower ear might lead to hearing loss (2). To the best of our knowledge, no study has evaluated the hearing loss as a possible consequence of ear injuries leading to cauliflower ear in wrestling. In this case-control study, we aim at finding the connection between cauliflower ear and hearing loss employing audometric tests.

3. Patients and Methods

This was a case-control study. The subjects were wrestlers between 15 to 25 years of age, with and without cauliflower ear, which were selected from 14 wrestling clubs in Tehran. All chosen subjects were wrestling regularly (not less than 3 sessions per week) for at least 1 year. Exclusion criteria were defined as employment in jobs with noise pollution, history of using ototoxic drugs, or congenital ear diseases either in the wrestlers or their first degree relatives.

Demographic data, history of either previous disease related to hearing loss, probable symptoms of hearing loss and risk factors for hearing loss (including history of noise overexposure, use of ototoxic drugs) were asked from subjects via an interview.

Examination of ears with an otoscope was performed for subjects in both cases and control groups. In this regard, the external canal and tympanic membrane of the wrestlers were observed carefully by an expert otolaryngologist and any obstruction in the external canal, perforation of tympanic membrane or other abnormalities were reported. Wrestlers in both groups underwent audiologic examinations including pure tone audiometry and impedance audiometry. These audiologic examinations were performed in a quiet place in each of the wrestling clubs but not in an audiometric test room.

Pure Tone Audiometry (PTA) was carried out for all wrestlers using a portable audiometer (Madsen DSA 84, Madsen Electronics, Copenhagen, Denmark). The hearing threshold at 0.5 to 8 KHz was assessed for the wrestlers; this range of frequencies was selected since it is reported as common speech frequencies (14, 15). A pure tone was delivered via headphones into the wrestlers’ ears and the results of the test were recorded. According to standard protocols, PTA should be performed in a silent and soundproof environment. As we performed the test in sport clubs, we tried to provide a condition with minimum noise and we applied a TDH39 headphone, which its ear pads entirely covers the ear’s auricles in order to decrease the effect of peripheral noises on testing and limits the auricles’ collapse. To evaluate the middle ears of the wrestlers the following two tests were performed as a part of impedance audiometry for all wrestlers:

1) Tympanometry was performed by an expert audiologist to obtain wrestlers’ ear tympanogram in both groups. In this regard, static compliance ranging from 0.3 to 1.6 cc and air pressure of the middle ear ranging from +50 to -100 daPa were assumed normal (15); 2) Acoustic reflex threshold was measured for all the wrestlers while data ranging 70 to 100 dB HL were considered as normal findings (16). If the test results showed normal “type A” tympanograms and normal acoustic reflexes, we would have ruled out conductive hearing loss, otherwise, wrestlers were referred for additional examinations and treatment.

Quantitative and qualitative variables were described as Mean (SD) and Frequency (percentage) using SPSS 20 (SPSS Inc, Illinois, USA), respectively. To account for intra-subject correlation between ear level measurements, Generalized Estimating Equation (GEE) logistic regression was used to estimate the odds ratios (95% CI) between cauliflower ear and hearing tests, adjusted for the potential confounding factors using Stata II (Stata Corp LP, College Station, USA).

In accordance with the written informed consent, signed by all the subjects before performing the study, wrestlers with complaint of hearing loss, were referred to audiology clinic for performing more sensitive diagnostic tests and also treatment. This study was also approved by the Ethical Committee of the Tehran University of Medical Sciences and study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki.

4. Results

In total, 340 subjects, including 201 wrestlers with cauliflower ears (100 wrestlers with one cauliflower ear and 101 wrestlers with two cauliflower ears) and 139 wrestlers without cauliflower ears were investigated in this study. The distribution of cauliflower ears in wrestlers according to their age, and months of wrestling training is provided in Table 1.

Symptoms of hearing loss in wrestlers with and without cauliflower ear are showed in Table 2. The percentage of positive history of ear infections among cauliflower
ears (8.4%) was about two times more than this finding among non-cauliflower ears (4.9%). This difference tended to be significant (OR: 1.86, 95% CI: 0.98 - 3.53, P = 0.06).

Also, results of otoscopic examination of external canal and tympanic membrane of the wrestlers’ ears are presented in Tables 3 and 4.

Pure tone audiometry examination results at frequencies ranging from 0.5 to 8 kHz showed that the frequency of hearing loss among cauliflower ears was higher than this rate among non-cauliflower ears. In our study, hearing loss was defined as above 25 dB HL decrease in hearing threshold according to basic values at each frequency (16). The results of pure tone audiometry at different measured frequencies are displayed in Tables 5 and 6.

Impedance audiometry, including tympanometry and acoustic reflex threshold results, showed that there is no significant association in odds ratio of clinically important parameters of the tests between cauliflower and non-cauliflower ears. The data of this audiologic test are provided in Table 7.

### Table 1. Distribution of Cauliflower Ear Among Wrestlers Participating in the Study According to Their Age and Months of Wrestling Training

| Variables | Months of Wrestling Training | Age | Number |
|-----------|-------------------------------|-----|--------|
| Wrestlers with one cauliflower ear | 68.1 (35.9) | 20.5 (2.5) | 100 |
| Wrestlers with two cauliflower ears | 73 (32) | 21.4 (3.2) | 101 |
| Wrestlers with no cauliflower ear | 51 (38) | 20.6 (2.7) | 139 |
| Total | | | 340 |

a n = 340.
b Statistically Significant: (P value < 0.05).
c Values are presented as Mean (SD)

### Table 2. Comparison Between the Frequency of Positive Symptoms of Hearing Loss in Wrestlers With and Without Cauliflower Ear

| Symptoms of Hearing Loss | Wrestlers With No Cauliflower Ear, % | Wrestlers With Cauliflower Ears, % | P Value |
|--------------------------|--------------------------------------|-----------------------------------|---------|
| Feeling of hearing loss  | 19.4                                 | 28.4                              | 0.06    |
| Talking loudly during wrestling training | 22.3 | 27.4 | 0.291 |
| Hearing noise in ears or head after course of training (Tinnitus) | 16.7 | 17.5 | 0.842 |
| Sensing fullness of the ears | 13.8 | 16.4 | 0.506 |

a Statistically Significant: (P value < 0.05).

### Table 3. Comparison of Abnormal Findings in Otoscopic Examination of External Canal of Cauliflower and NON-Cauliflower Ears

| Findings of Otoscopic Examination (For Ear Canal) | Non-Cauliflower Ears, % | Cauliflower Ears, % | P Value |
|--------------------------------------------------|-------------------------|---------------------|---------|
| Ear wax (little)                                 | 15.9                    | 16.6                | 0.75    |
| Ear wax (large)                                  | 6.1                     | 9.1                 | 0.049   |
| Inflammation                                     | 0                       | 0                   |         |
| Deformity                                        | 0                       | 0                   |         |
| Canal stenosis                                   | 0                       | 3.1                 | 0.16    |

a Statistically Significant: (P value < 0.05).

### Table 4. Comparison of Abnormal Findings in Otoscopic Examination of Tympanic Membrane of Cauliflower and Non-Cauliflower Ears

| Findings of Otoscopic Examination (For Tympanic Membrane) | Non-Cauliflower Ears, % | Cauliflower Ears, % | P Value |
|----------------------------------------------------------|-------------------------|---------------------|---------|
| Retraction                                               | 1.1                     | 6.2                 | 0.2     |
| Inflammation                                             | 2.9                     | 2                   | 0.43    |
| Perforation                                              | 3.0                     | 3.1                 | 0.19    |
| Plaque                                                   | 3.5                     | 3.4                 | 0.53    |

a Statistically Significant: (P value < 0.05).
Table 5. Association Between Percentages of Hearing Loss in Cauliflower Ears and Non-Cauliflower Ears at Different Frequencies \(^a\)

| Frequency, KHz | Percentage of Ears With Hearing Loss, % | OR  | CI 95% | P Value | Adjust OR \(^b\) | CI 95% |
|---------------|---------------------------------------|-----|--------|---------|-----------------|--------|
|               | Non-cauliflower Ear                   |     |        |         |                 |        |
| 0.5           | 11.9                                  | 24.8| 1.99   | 0.001\(^c\) | 2.10           | 0.80 - 2.28 |
| 1             | 1.1                                   | 7.0 | 4.11   | 0.005\(^c\) | 4.39           | 1.51 - 3.29 |
| 2             | 2.9                                   | 9.3 | 3.03   | 0.003\(^c\) | 3.11           | 0.96 - 3.29 |
| 3             | 9.0                                   | 15.2| 1.66   | 0.038\(^c\) | 1.62           | 1.00 - 2.64 |
| 4             | 14.3                                  | 21.2| 1.52   | 0.045\(^c\) | 1.45           | 1.50 - 6.45 |
| 6             | 15.1                                  | 29.1| 2.20   | <0.001\(^c\) | 2.23           | 1.60 - 12.26 |
| 8             | 8                                     | 12.3| 1.3    | 0.80 - 2.24 | 0.273          | 1.35   | 1.39 - 3.18 |

\(^a\) Abbreviations: CI, Confidence interval; OR, Odds ratio; SD, Standard Deviation.
\(^b\) Adjusted for age, findings of otoscopic examination for tympanic membrane and noise over exposure.
\(^c\) Statistically Significant: (P value < 0.05).

Table 6. Association Between Pure Tone Audiometry Results in Cauliflower Ears and Non-Cauliflower Ears at Different Frequencies \(^a\)

| Frequency, KHz | Mean (SD) | P Value | CI 95% |
|----------------|-----------|---------|--------|
|                | Non-cauliflower Ear | Cauliflower Ear | |
| 0.5            | 22.59 (4.89) | 24.78 (7.28) | 0.001\(^c\) | 1.14 - 3.35 |
| 1              | 20.11 (3.44) | 21.27 (5.09) | 0.006\(^c\) | 0.33 - 1.97 |
| 2              | 19.99 (4.47) | 21.64 (6.21) | 0.002\(^c\) | 0.59 - 2.52 |
| 3              | 21.66 (7.84) | 23.16 (8.45) | 0.041\(^c\) | 0.06 - 2.89 |
| 4              | 14.32 (10.62) | 24.97 (10.41) | 0.037\(^c\) | 0.11 - 3.62 |
| 6              | 23.61 (10.24) | 26.56 (11.47) | 0.002\(^c\) | 1.03 - 4.55 |
| 8              | 21.23 (7.63) | 22.75 (10.41) | 0.046\(^c\) | 0.03 - 3.00 |

\(^a\) Abbreviations: CI, Confidence interval; SD, Standard Deviation.
\(^b\) Adjusted for age, months of wrestling training, findings of otoscopic examination for tympanic membrane and noise over exposure.
\(^c\) Statistically Significant: (P value < 0.05).

Table 7. Association of Abnormal Findings in Impedance Audiometry Test Between Cauliflower and Non-Cauliflower Ears \(^a,b\)

| Factor of Measurement | OR   | 95% CI       | P Value |
|-----------------------|------|--------------|---------|
| AR abnormal \(^c\)    | 0.67 | 0.36 - 1.26  | 0.21    |
| SA > Normal \(^d\)    | 0.97 | 0.48 - 1.96  | 0.93    |
| SA < Normal \(^d\)    | 0.69 | 0.41 - 1.18  | 0.17    |
| TPP < Normal \(^e\)   | 2.54 | 0.23 - 28.1  | 0.45    |
| ECV > Normal \(^f\)   | 3.97 | 0.87 - 18.1  | 0.08    |
| ECV < Normal \(^f\)   | 0.76 | 0.57 - 1.00  | 0.06    |

\(^a\) Abbreviations: CI, Confidence Interval; OR, Odds Ratio.
\(^b\) Statistically Significant: (P value < 0.05).
\(^c\) AR: Acoustic Reflex; [AR abnormal defined as AR > 110].
\(^d\) SA: Static Admittance; [SA > Normal defined as SA > 1.7]; [SA < Normal defined as SA ≤ 0.3).
\(^e\) TPP: Tympanometric Peak Pressure; [TPP < Normal defined as TPP < 100].
\(^f\) ECV: Equivalent Canal Volume; [ECV > Normal defined as ECV ≥ 2]; [ECV < Normal defined as ECV < 0.9].

5. Discussion

To the best of our knowledge, this is the first study using audiologic tests at different frequencies, showing that the rate of hearing loss in wrestlers with cauliflower ear is higher than this rate among a control group of wrestlers without cauliflower ear. According to the results of PTA, hearing loss in all frequencies was significantly higher in cauliflower ears, except 8 kHz frequencies. This might imply the importance of establishing preventive policies like mandatory use of ear gears. Our finding supported results of previous study by Kordi et al. (2) which was a questionnaire based survey reporting significant differences between the rates of hearing loss in wrestlers with cauliflower ear (11.5%) in comparison with wrestlers without cauliflower ear (1.8%) (P < 0.05).
The percentage of positive history of ear infections in wrestlers with cauliflower ear was about twice this rate among other group of wrestlers. Although this finding was not statistically significant, it could be considered as a possible reason for higher rate of hearing loss in cauliflower ears; thereby, ear infection prevention and on time treatment of ear infections may be recommended to prevent possible hearing loss in wrestlers. In this regard, partial obstruction of ear canal in cauliflower ears, may increase the probability of collection of pathogenic microorganisms in the ear canal and thereby increase the rate of infection in such ears. Direct trauma to the external ear, which happens in many contact sports such as wrestling, could indirectly damage the middle and inner ear as well.

To evaluate the effect of probable direct trauma and abrasions (as the major mechanisms leading to cauliflower ear in wrestlers) on the middle ear, the impedance audiometry was also performed for all wrestlers. According to the results of impedance audiometry, it was found that there is no significant difference in rate of abnormal acoustic reflex between cauliflower and non-cauliflower ears. As acoustic reflex test implies the intensity of stapedius through movement of tympanic membrane through generation of a loud sound. With respect to the mentioned findings, it may be concluded that there is no significant difference in the rate of diseases involving the stapedius muscle at its innervating nerve branch between the cauliflower ears in comparison with non-cauliflower ears, although some false negative conditions have also been described for this test (17-19).

According to the results of acoustic reflex test, even though cauliflower ears have suffered from more possible trauma, they do not have significant abnormalities in comparison with non-cauliflower ears. This finding may be due to the type of trauma that usually leads to cauliflower ear since abrasion and blunt trauma can have less effect on the middle ear of the wrestlers due to its inner anatomical position as opposed to external ear.

As it is shown by the results, the static admittance in cauliflower ears was not found to be significantly higher than this rate in other group. It may imply that there is no significant connection between the severity of tympanic membrane tenacity of both groups leading to a non-significant relationship between the maximum compliance of the middle ear in the groups.

The number of wrestlers in case group with low Equivalent Canal Volume (ECV) was higher; in addition, the number of external canal stenosis found in cauliflower ears group was higher than non-cauliflower ears. These may be due to the role of fullness and stenosis of the canal in hearing loss of wrestlers with cauliflower ears (20, 21).

Considering the PTA and impedance results, it could be suggested that the resonant frequency of the external auditory canal has been changed, and this finding might be due to repetitive minor traumas to the cartilaginous part of external canal. As a limitation of the study, the audiological tests were performed in the wrestling clubs. While according to standard protocols, the tests should be done in a sound protected place. In this regard, a quite silent condition in a private room in the wrestling clubs was provided for performing the audiologic tests. Also, bone conduction testing was not performed on wrestlers, therefore, we could not differentiate the type of hearing loss (sensorineural, conductive, or mixed). However, due to the effect of environmental noises on the PTA data in 0.5 KHz, the percentage of wrestlers with hearing loss in this frequency has increased in both with and without cauliflower ear groups. If this frequency is ignored, the maximum number of wrestlers with hearing loss would be in the 4 and 6 KHz frequencies (higher frequencies). Therefore, despite the importance of bone conduction audiometry for determination the type of hearing loss, it doesn’t seem useful for interpreting the study’s findings. This study was a retrospective study and more prospective studies might be needed to confirm our finding that hearing loss is a consequence of ear injuries that lead to cauliflower ears. However, within our limitations, we recommend that wrestlers wear ear protectors during wrestling training and promptly treat their ear hematoma.

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Authors’ Contributions

All authors contributed equally to this paper.

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