

# Auditory Exostosis in Australian Warm Water Surfers: a Cross-sectional Study

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## Research Article

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# Abstract

## Background

Surfing is a popular sport in Australia, accounting for nearly 10 percent of the population. External auditory exostosis (EAE), also referred to as surfer's ear, is recognized as a potentially serious complication of surfing. Cold water (water temperature below 19°C) is a commonly cited risk factor, with prevalence of EAE in cold water surfers ranging from 61 to 80 percent.

However, there is a paucity of studies reporting the prevalence of EAE in surfers exposed to water temperatures above 19°C. With mean water temperature ranging from 19°C to 28°C, the Gold Coast region of Australia provides the ideal environment to assess the main goal of this study: to assess the prevalence and severity of EAE in warm water surfers.

## Methods

Eligible participants were surfers living and surfing on the Gold Coast (Queensland, Australia). Currently active surfers over 18 years of age, surfing year-round, with a minimum of five consecutive years of surfing experience were recruited to participate. Included individuals were asked to complete a questionnaire and underwent bilateral otoscopy.

## Results

A total of 85 surfers were included, with mean age 52.1 years (standard deviation [SD]  $\pm 12.6$  years) and mean surfing experience of 35.5 years (SD  $\pm 14.7$  years). Nearly two-thirds of participants (65.9%) had regular otological symptoms, most commonly water trapping (66%), hearing loss (48.2%), and cerumen impaction (35.7%). Less than one-fifth of the surfers (17.7%) reported regular use of protective equipment for EAE. The overall prevalence of exostosis was 71.8%, with most of the individuals having bilateral lesions (59%) and a mild grade (grade 1, 47.5%). There was insufficient evidence for any significant associations between the main outcomes (presence and severity of EAE) and factors related to age, surfing experience, winter exposure, surfing ability, symptoms, and use of protective equipment.

## Conclusion

To the best of our knowledge, this is the first study assessing EAE in surfers exposed to warm waters (above 19°C). The prevalence of 71.8% highlights the high prevalence of the condition in the surfing population, regardless of water temperature. Future research should focus on ways to prevent EAE.

## Key Points

- This study examines the prevalence and severity of external auditory exostosis (EAE) in warm water surfers, a relatively unexplored topic in the literature.

- The overall prevalence of EAE in warm water surfers of the Gold Coast region of Australia found in the present study was 71.8%.
- Nearly 60% of the participants had bilateral lesions.
- Recurrence rate of the condition after surgical removal was 50%.
- Future research should focus on effective preventive methods for EAE.

## Background

Surfing is a popular sport in Australia, with the estimated number of participants over 2.5 million, accounting for nearly 10 percent of the nation's population.[1] Exostosis of the external auditory canal (EAC), also referred to as surfer's ear, is recognized as a potentially serious complication of surfing.[2, 3] Commonly multiple and found bilaterally, external auditory exostosis (EAE) is an irreversible benign condition. Exostosis can be associated with a variety of clinical features, including an intermittent blocked feeling of the EAC, especially after water exposure, recurrent cerumen blockage, frequent ear infections, pain in the EAC, and hearing deterioration due to the obstructive nature of the condition.[3]

The pathophysiology and prevention of EAE remain unclear. The consistent use of protective equipment, such as earplugs and hoods, has been proposed to prevent its occurrence and is advised [4, 5]; however, the efficacy of these preventative measures remains to be established. Surgery is the only treatment, and it is usually reserved for patients with severe and symptomatic cases; however, the surgical procedure does not prevent recurrence.[6, 7]

It is well acknowledged that there is a positive association between the amount of time spent surfing and the presence and severity of EAE, with risk increasing after only five sessions per month and significantly increasing after five years surfing.[5, 8] Regarding the relationship between EAE and water temperature, cold water (water temperature below 19°C) is a commonly cited risk factor, with prevalence of EAE in cold water surfers ranging from 61 to 80 percent.[9–17] Additionally, anthropological data indicate that regions located more than 30° north or south of the equator line, where the annual average water temperature is below 19°C, have a high prevalence of EAE.[9] Nevertheless, there is a paucity of studies reporting the prevalence of EAE in surfers exposed to water temperatures above 19°C.

Located at 28° south of the equator, the Gold Coast region of Australia is world-famous for its surf breaks, with mean water temperature ranging from 19 to 22°C in August (winter), through to 26 to 28°C in February (summer).[18] It thus provides the ideal environment in which to address the main goal of this study: to assess the prevalence and severity of EAE in warm water surfers.

## Methods

### Study design

This research used a cross-sectional observational design, aiming to investigate the prevalence and severity of auditory exostosis in Australian warm water surfers. The study was approved by the Bond University Human Research Ethics Committee (BUHREC 15221).

## **Participants**

Surfers were recruited through advertising in a local paper and from local boardrider clubs in the Gold Coast (GC) area (City of Gold Coast, Queensland, Australia). Additional support for recruitment was obtained from surfing magazines, websites and local surf shops in the GC area. Participants or the public were not involved in the design, or conduct, or reporting, or dissemination of our research.

### **- Eligibility criteria**

Only individuals living and surfing in the GC region were considered to be included. Currently active surfers over 18 years of age, surfing all year round, with a minimum of 5 consecutive years of surfing experience, surfing at least five sessions per month, were invited to take part in the research. Surfers were excluded from the study if they had a history of exposure to cold water (mean temperature below 19°C) for more than 3 consecutive weeks, if they participated for more than 3 consecutive weeks in winter sports activities (e.g., skiing, snowboarding), or if they have lived in cold regions (located more than 30° north or south of the equator) for more than 5 consecutive years in their lifetime. Additionally, participants were excluded if both the right and left EAC were occluded by cerumen.

## **Procedures**

As described in our previous studies,[19, 20] all participants who successfully passed the initial screening were invited to participate in this study. The research took place at the Water Based Research Unit (WBRU), Bond Institute of Health and Sport, Bond University, Gold Coast (Queensland, Australia). An explanatory statement and consent form were given to all participants upon arrival at the WBRU. Prior to providing written informed consent, all potential participants were given the opportunity to ask any questions about the research and about the testing procedure.[19, 20] The explanatory statement illustrated the exam to be conducted, and contained a simple overview of the research project and its purpose.[19, 20] The informed consent form was signed once participants were satisfied with the information provided.

At the WBRU, participants were asked to complete a questionnaire to collect basic demographic data and to examine their surfing habits and otological history, as described in our previous studies.[19, 20] After completing the questionnaire, and in line with the methodology previously adopted by our research team, [19, 20] all participants underwent clinical examination of both ears, via otoscopy, by an experienced Sport and Exercise Physician, using a hand-held, battery-powered digital otoscope (Digital MacroView™, Welch Allyn®, USA), capable of acquiring digital images.

## **Predictors and outcome measures**

## - Surfing characteristics

Surfers were assessed with regard to surfing specific characteristics, which included: surfing experience in years; average number of sessions per week; average number of hours per session; winter exposure in hours (number of hours per session during winter multiplied by number of sessions during winter and number of years surfing); surfing ability, as measured by the Hutt scale [21]; stance while surfing (i.e., 'regular' if left foot forward or 'goofy' if right foot forward); and main type of surfboard (short, minimal/funboard, or longboard). Additionally, they were asked whether they were involved in any other ocean sport.

## - Otological history

Participants were asked about the presence of otological symptoms (e.g., otalgia, hearing loss), regular use of prevention methods for EAE (e.g., ear plug, hood), and previous history of otitis externa (OE) and EAE.

## - Exostosis

During otoscopy, images of the EAC were recorded, and all images were assessed to determine the presence of EAE. If present, the degree of obstruction of the EAC was graded on the standard clinical one-to-three scale (Fig. 1; grade 1: up to 33% of obstruction; grade 2: between 34–66% of obstruction; grade 3: more than 67% of obstruction), as previously described.[16]

## Data analysis

Continuous data were analyzed descriptively to determine means and standard deviations (SD) and tested for normality by assessing skewness, kurtosis, Q-Q plots, and the Kolmogorov-Smirnov test. Categorical outcomes were summarised using frequencies and percentages. A Chi-square test of independence was used to assess associations between the main outcome variables (EAE presence and severity) and categorical outcomes. The level of significance, alpha, was set *a priori* at 0.05 for all statistical tests. All analyses were performed with SPSS statistical software (Version 25.0 for Windows, SPSS Inc., Chicago, IL, USA, 2017).

## Results

Initially, an intra-rater reliability study was conducted as a single clinician (Specialist) assessed the severity of exostosis in all participants. It is common practice to assess the intra-rater reliability of clinicians, [22] particularly when the diagnosis and/or grading is subjective, as is with EAE.[23] A total of 15 EAE images were selected from a pool of approximately 970 images to determine the inter-rater reliability. The reliability between test-retest was 100% by the clinician. We then completed a quantification analyses where we utilized the freely available software *ImageJ*, developed by the National Institutes of Health (Bethesda, MD, USA), which is specifically designed for medical and/or biological analyses with a shown high validity ( $r = 0.988$ ) and reliability (Cronbach's alpha = 0.994).[24] This

software is used in a number of medical fields, including computerized tomography analyses, blood vessel diameter analyses, abdominal and skeletal muscle mass, and wound healing.[25] However, to the best of our knowledge, it has not previously been used in determining the severity of exostosis. However, we have recently shown this technique to have a high coefficient of reliability ( $r = 0.999$ ), and a significant correlation (total area and exostosis area,  $p < 0.01$ ,  $r = 0.999$ ), and a near perfect positive relationship between repeated measurements.[26] Therefore, we deemed this quantification technique of exostosis appropriate to assess the clinicians analyses of exostoses in our participants. There was 100% agreement between the clinician's assessment of the severity of exostosis and our quantification method.

A total of 85 surfers were eligible to take part in our study (eighty-one males, 95.3%), with a mean age of 52.1 years ( $SD \pm 12.6$ ). Participants had a mean surfing experience of 35.5 years ( $SD \pm 14.7$ ), surfing on average 3.8 times per week ( $SD \pm 1.8$ ), and each session having a mean duration of 1.7 hours ( $SD \pm 0.5$ ). Age, surfing experience, winter exposure, and surfing ability were grouped in categories, and these are shown in Table 1. The majority of the individuals had a regular stance (left foot forward, 78.8%) and used a shortboard (72.9%) as the main type of surfboard. Nearly half of the participants (49.4%) were regularly involved in other ocean sports, most commonly swimming (17.6%) and stand-up paddle boarding (12.9%).

**Table 1** Demographic characteristics of surfers ( $N = 85$ )

Characteristics	<i>n</i>	Percent
Age		
- 18 to 30 years	6	7.1%
- 31 to 50 years	28	32.9%
- 51 to 75 years	51	60.0%
Surfing experience		
- Less than 10 years	6	7.1%
- 11 to 25 years	20	23.5%
- 26 to 50 years	46	54.1%
- More than 50 years	13	15.3%
Winter exposure		
- Less than 1500 hours	35	41.2%
- 1500 to 3000 hours	24	28.2%
- More than 3000 hours	26	30.6%
Surfing ability (Hutt scale [ <sup>21</sup> ])		
- Beginner	2	2.4%
- Intermediate	57	67.1%
- Advanced	26	30.6%
Abbreviation: <i>n</i> , number of individuals.		

With regards to otological history, almost two-thirds of the surfers (65.9%) reported having regular symptoms and, of these, 62.5% had two or more symptoms. The most common complaint was water trapping (66%), followed by hearing loss (48.2%) and cerumen impaction (35.7%). Despite the high prevalence of otologic symptomatology, less than one-fifth of the participants (15 individuals) reported regular use of prevention methods. Earplugs ( $n = 5$ ), alcohol-based ear drops ( $n = 5$ ), and hoods ( $n = 2$ ) were the preventive methods employed by the surfers. Three individuals used a combination of these three methods. Thirty-five surfers (41.2%) reported ear infection in the past, and 20 (23.5%) reported having EAE diagnosed by either their General Practitioner (GP) or a specialist physician, with four of these surfers (20%) having had previous surgical removal of exostosis.

Some degree of exostosis (grade 1 to 3, inclusive) was present in 61 individuals (71.8%, Fig. 2), of which 36 (59%) had bilateral lesions, with similar prevalence in left and right sides (56.5% and 57.6%,

respectively, no significant difference). With regards to severity (Fig. 3), nearly half of the individuals with EAE had only a minor grade (grade 1, 47.5%), 22.4% had grade 2, and only 15.3% were classified as having a severe grade of EAE (grade 3). Of those four individuals who had EAE surgically removed, two (50%) had new lesions on the operated side, and both individuals were classified as having grade 2 (between 34–66% of obstruction).

A Chi-square test of independence was used to analyze the association between the presence of EAE and the following predictor variables: age group, surfing experience group, winter exposure group, surfing ability group, participation in other ocean sports, presence of otological symptoms, use of protective equipment, and previous history of OE. There was no correlation between any of the predictor variables and the outcome. Additionally, a Chi-square test of independence was also used to analyze the relationship between the same predictors and the severity of EAE, again with no statistically significant results. However, when analyzing associations between predictor variables and potential confounding factors, there was a statistically significant association between the presence of hearing loss and age ( $\chi^2(1) = 3.901, p = 0.048$ ).

## Discussion

### Main findings

The primary goal of the present research was to determine the prevalence of EAE in warm water surfers. To the best of our knowledge, this is the first study to assess the presence of EAE in surfers exclusively exposed to water temperatures above 19°C. The overall prevalence of the condition in our study was 71.8%. Considering that approximately 10% of the Australian population regularly surf,[1] this condition potentially affects nearly 45,000 individuals on the Gold Coast region of Australia.

The current study found that otological symptoms are common in the surfing population, as nearly two-thirds of the participants reported having regular symptoms; however, hearing loss, a common symptom associated with EAE, due to the obstructive characteristic of the condition, was significantly associated with age. Furthermore, we did not find a statistically significant association between symptoms and either the presence or severity of EAE. Also, these outcomes were not associated with the most commonly cited risk factors, namely surfing experience and winter exposure, or with the use of prevention methods.

### Relation to previous studies

This prevalence is comparable to what has been previously reported for cold water surfers, with results ranging from 61 to 80%.[9–17] Moreover, this prevalence is in line with a previous study conducted by Hurst et al.[15] in Victoria, Australia, where the authors reported a prevalence of 76%. Interestingly, a second study conducted in Australia, via an online survey, identified less than 4% of the surfers (3.5%) reported having EAE.[27] A likely explanation for the difference between self-reported and assessed prevalence is the potential lack of awareness of surfers about EAE. It is important to highlight that our study had the highest mean age (52.1 years  $\pm$  12.6) and the greatest number of years of surfing

experience (35.5 years  $\pm$  14.7), when compared to previous studies. Nonetheless, our main finding highlights that EAE is highly prevalent in surfers, regardless of water temperature. Additionally, it further supports the concept that surfing exposure is potentially the most important predictor of EAE prevalence.

Nearly sixty percent of our volunteers had bilateral lesions, consistent with what has been previously reported in the literature. Some studies have suggested that the ear (right or left) more exposed to the prevailing wind would have a higher prevalence of EAE and more severe lesions.[10, 15, 28] The predominant coastal wind on the Gold Coast region is south-southeast (SSE) [29]; however, there was no evidence of a statistical difference in prevalence and severity of EAE between the right and left ears of participants. With regards to severity, the majority of the volunteers in our study (47.5%) only had a mild grade EAE (grade 1), a result that is consistent with previously reported findings. Four individuals (6.6% of those with EAE) who had undergone EAE surgery, had a recurrence rate of 50%. Although surgery is the only treatment for the condition, recurrence is common, even in individuals who stop participation in ocean sports.[6, 7]

## Limitations

It is important to note that the findings of this study must be interpreted with caution, mainly due to the study design, but also due to the relatively low number of participants in the study.

## Conclusion

The purpose of the current study was to assess the lifetime prevalence of EAE in warm water surfers. To the best of our knowledge, this is the first study assessing exostosis in surfers surfing exclusively in water temperatures above 19°C. Our findings revealed a prevalence of 71.8%, demonstrating that exostoses of the EAC are highly prevalent in warm water surfers, just as they are in cold water surfers. Furthermore, the results support the impression that surfing experience is potentially the most important predictor of prevalence. Health practitioners, especially General Practitioners and medical specialists, should be aware of this EAE prevalence in their surfing (and aquatic) patients and approach individuals susceptible to the condition, regardless of water temperature, in order to provide preventive recommendations for this population. Future research should focus on effective preventive methods for EAE.

## List Of Abbreviations

- EAC: external auditory canal
- EAE: external auditory exostosis
- BUHREC: Bond University Human Research Ethics Committee
- GC: Gold Coast
- WBRU: Water Based Research Unit
- OE: otitis externa
- SD: standard deviation

- N: number of individuals

## **Declarations**

### **Ethics approval and consent to participate**

The study was approved by the Bond University Human Research Ethics Committee (BUHREC 15221). An explanatory statement and consent form were given to all participants. Prior to providing written informed consent, all potential participants were given the opportunity to ask any questions about the research and about the testing procedure. The informed consent form was signed once participants were satisfied with the information provided. All procedures performed in the present study were in accordance with the ethical standards of the Bond University Human Research Ethics Committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

### **Consent for publication**

Not applicable.

### **Availability of data and material**

All data generated or analysed during this study are included in this published article.

### **Competing interests**

VS, WH, ER, RP, and MC declare that they have no competing interests.

### **Funding**

VS was supported by an Australian Government Research Training Program Scholarship.

### **Authors' contributions**

VS created and designed the research study, recruited appropriate participants, collected data, performed all otoscopic examinations, created datasets, led data analyses, data interpretations, and wrote the manuscript.

WH assisted with study design, supported data analyses, manuscript review and editing.

ER assisted with data analyses, data interpretation, manuscript review and editing.

RP assisted with study design, supported data analyses, and manuscript review and editing.

MC assisted with study design, assisted with data analyses, and manuscript review and editing.

All authors read and approved the final manuscript.

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## Figures

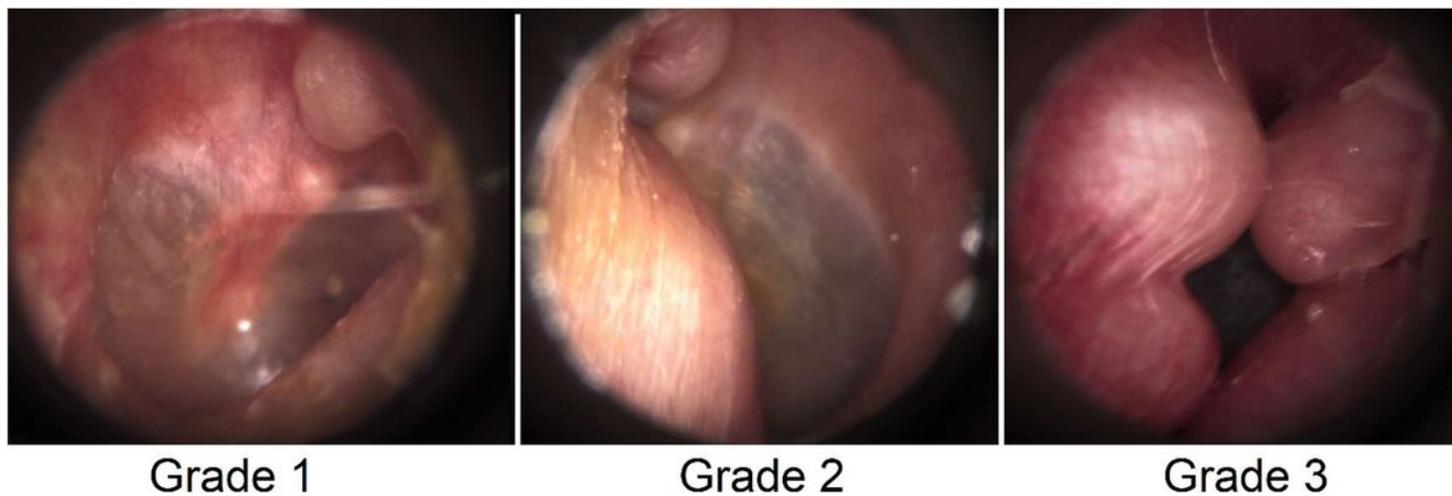


Figure 1

Exostosis severity Notes: Grade 1: up to 33% of obstruction of the external auditory canal (EAC); Grade 2: between 34% and 66% of obstruction of the EAC; Grade 3: more than 67% of obstruction of the EAC.

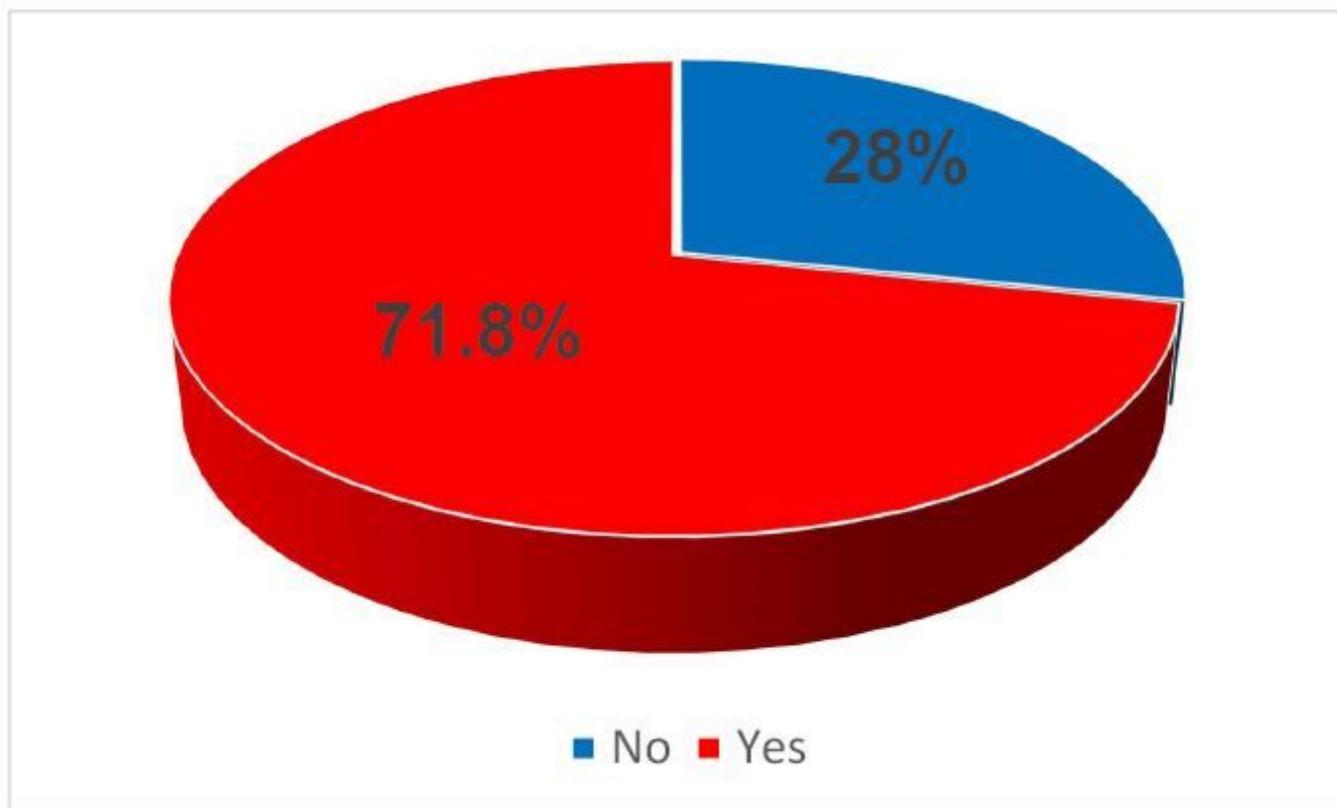
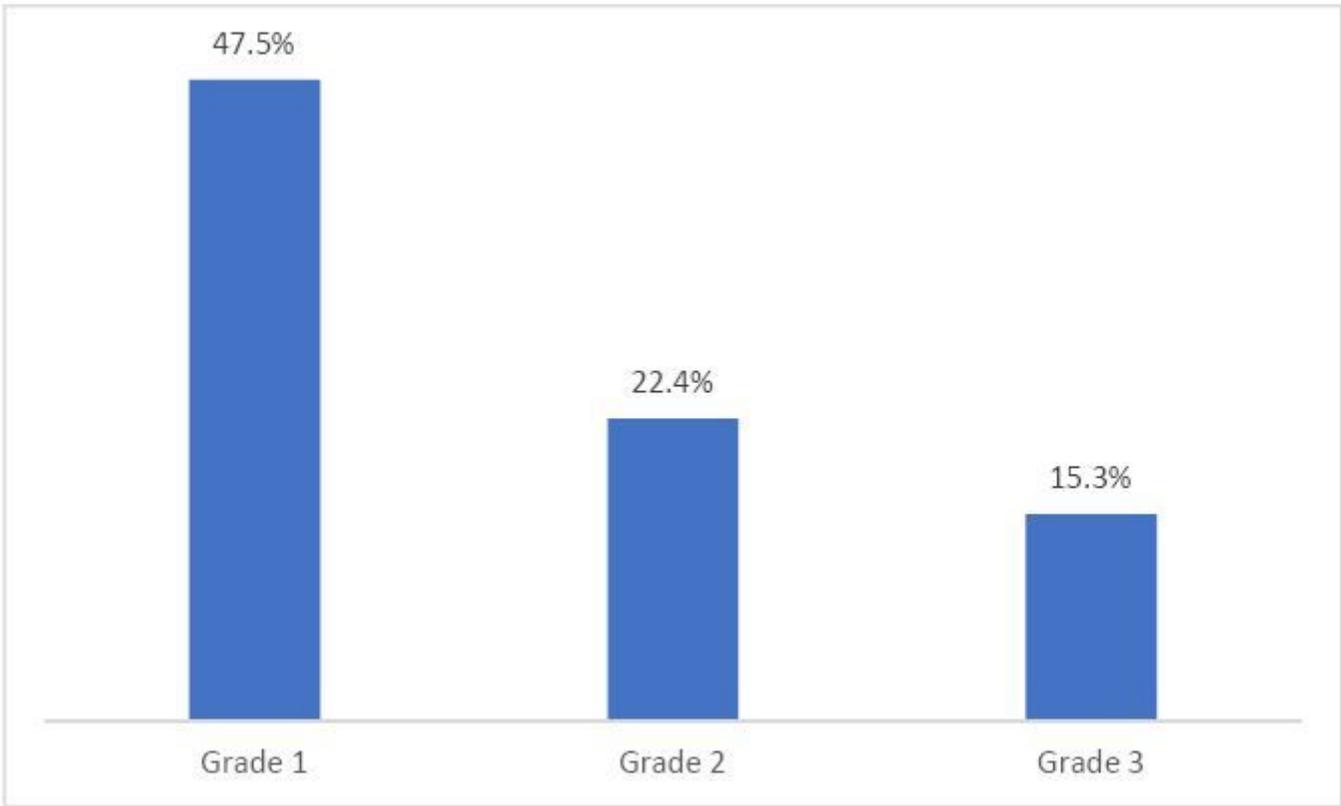


Figure 2

Prevalence of auditory exostosis in 85 surfers



**Figure 3**

Severity of auditory exostoses in 85 surfers