Revista Chilena de Fonoaudiología 22(1), 1-7
https://revfono.uchile.cl/
ISSN 0719-4692

Original Article

Prevalence of External Auditory Canal Exostosis among Surfers and Bodyboarders from the Central Coast of Chile

Carlos Orellana [a], Paula Plaza [b], Cristian Poblete [a], Jan Karlsruher [c] and Gonzalo Gallardo [a]

[a] *Escuela de Fonoaudiología, Facultad de Ciencias de la Rehabilitación, Universidad Andrés Bello, Viña del Mar, Chile.*
[b] *Exercise and Rehabilitation Sciences Laboratory, School of Physical Therapy, Faculty of Rehabilitation Sciences, Universidad Andrés Bello, Santiago, Chile.*
[c] *Escuela de Medicina. Universidad Andrés Bello, Viña del Mar, Chile.*

ABSTRACT

External auditory canal exostosis (EACE), also known as surfer's ear, is a bone tissue disturbance in the outer ear, mainly caused by overexposure to cold temperatures. Considering that people who practice water sports such as surfing and bodyboarding on the Pacific coast are exposed to waters at temperatures between 12-16 °C, this study aimed to determine the prevalence and severity of EACE in surfers and bodyboarders from Reñaca and Concón, two coastal cities in the southern Pacific Ocean, during the year 2018. An EAC evaluation was carried out through video otoscopy on 67 people (134 ear canals) who practiced surfing and bodyboarding on the beaches of Reñaca and Concón, and a questionnaire was used to collect information about their practice habits. As a result, an EACE prevalence of 77.6% was found, with 61.2% being bilateral and 16.4% unilateral. Additionally, it was observed that 62.3% of the participants do not use ear protection. Based on these findings, it is possible to conclude that there is a high prevalence of EACE in surfers and bodyboarders from the central coast of Chile, which should alert both the population of people who practice these water sports and the professionals who work with auditory health of the necessity to promote a healthy lifestyle in this population.

Keywords:
Exostosis; External Auditory Canal; Prevalence; Water Sports; Surfers' Ear

Prevalencia de la exóstosis del conducto auditivo externo entre practicantes de *surf* y *bodyboard* en la costa central de Chile

RESUMEN

La exóstosis del conducto auditivo externo (ECAE), también conocida como oído de surfista, es una alteración del tejido óseo del oído externo, principalmente causada debido a la sobrexposición al frío. Considerando que los practicantes de deportes acuáticos como el *surf* y *bodyboard* de las costas del pacífico sur se exponen a aguas con temperaturas entre 12-16 °C, se busca determinar, en este estudio, la prevalencia y grado de ECAE en practicantes de *surf* y *bodyboard* de las localidades de Reñaca y Concón durante el año 2018. Se realizó una evaluación del CAE mediante video-otoscopía a 67 personas (134 oídos) practicantes de *surf* y *bodyboard* de las playas de Reñaca y Concón, y se les aplicó un cuestionario respecto a sus hábitos de práctica. Como resultado, se observó una prevalencia de ECAE del 77,6%, siendo el 61,2% ECAE bilateral y el 16,4% ECAE unilateral. Se pudo determinar, además, que el 62,3% de los participantes no usa protecciones. A partir de estos hallazgos, es posible concluir que existe una alta prevalencia de la ECAE en practicantes de *surf* y *bodyboard* en las costas centrales chilenas, lo que debería alertar tanto a la población practicante como a profesionales de la salud auditiva con el fin de promover una vida saludable en esta población.

Palabras clave:
Exóstosis; Conducto Auditivo Externo; Prevalencia; Deportes Acuáticos; Oído de Surfista

**Corresponding Author: Paula Plaza*
E-mail: paula.plaza@unab.cl

Received: 12-20-2021
Accepted: 01-03-2023
Published: 03-10-2023

INTRODUCTION

External auditory canal exostosis (EACE), also known as surfer's ear, is characterized by the presence of benign bone neoformations, generally bilateral and with a broad base, on the anterior and posterior walls of the external auditory canal (Altuna Mariezkurrena et al., 2004; Landefeld et al., 2022; Simas et al., 2016).

EACE has a high incidence in populations of athletes who are exposed to water, reaching between 60% and 80% in surfers (Attlmayr & Smith, 2015; Kroon et al., 2002; Lennon et al., 2016; Nakanishi et al., 2011; Simas et al., 2019, 2021), 70% in kayakers (Cooper et al., 2010; Moore et al., 2010), 75.1% in kitesurfers (Wegener et al., 2022), and exceeding 80% in divers (Azizi, 2011). This has been reported by athletes from different parts of the world, for whom the common factor is permanent exposure of the auditory canal to water (see Table 1).

Table 1. Prevalence of exostosis in surfers from different countries, adapted from Lennon et al. (2016).

Authors	Year	N	Country	Temp. (°C)	%EACE
Lennon et al.	2014	119	Ireland	8–15	66
Nakanishi et al.	2011	373	Japan	16–19	59.8
Altuna et al.	2004	42	Spain	12–19	61
Hurst et al.	2004	111	Australia	13–19	76
Kroon et al.	2002	33	USA	<15.5	63
Kroon et al.	2002	169	USA	>15.5	31
Wong et al.	1999	307	USA		73.5
Chaplin and Stewart	1998	92	New Zealand	10–24	73
Deleyiannis et al.	1996	30	USA	6–15	70
Umeda et al.	1989	51	Japan	9.5–14.5	80

N: Number of participants in the study; Country: location where the study took place; Temp.: Temperature of the sea.

Regarding the etiopathogenesis of surfer's ear, two hypotheses can be found. One proposes that the irritation occurring in the EAC due to repeated and prolonged contact with cold water stimulates osteoblastic activity, which leads to bone growth that results in EACE (Wong et al., 1999). The other links EACE to an increase in BMPs (bone morphogenetic proteins), a growth factor that stimulates bone formation in the presence of mechanical stress (Chen et al., 2004; Sato et al., 1999).

It should be noted that, regardless of its etiopathogenesis, the gradual growth of bone typically observed in EACE is initially asymptomatic, therefore, it is not usually detected at early stages. On the other hand, the treatment for severe EACE is surgical (Altuna Mariezkurrena et al., 2006; Wong et al., 1999), implying, among other measures, that the person must stop their water activities for at least 3 months after surgery. It is for this reason that early detection, and even more so prevention, are key. In this sense, it has been shown that the use of ear protection is effective in reducing the development of EACE in surfers (Lambert et al., 2021).

The Valparaíso Region is one of the southernmost areas of the planet (located between parallels 32-33° south latitude in the Pacific Ocean) where water sports such as surfing and bodyboarding have become popular. According to the Chilean Navy Hydrographic Oceanographic Service (*Servicio Hidrográfico Oceanográfico de la Armada*, or SHOA), the Sea Surface Temperature (SST) in the region does not exceed 16°C in summer, while in winter it does not exceed 12°C. However, to date, the prevalence of EACE in this low-temperature area is unknown. The southernmost data known is of the prevalence of EACE in surfers on the coast of Australia, located around parallel 28 south latitude, where the waters reach an SST above 19°C (Simas et al., 2021).

Therefore, the purpose of the study is to determine the prevalence of exostosis in the external auditory canal, as well as to identify the use of ear protection during 2018 in surfers and bodyboarders of one of the southern areas with the coldest waters to practice these sports, particularly, the towns of Reñaca and Concón in the Valparaíso Region, Chile.

MATERIALS AND METHODS

This is a descriptive, cross-sectional study, that follows a quantitative approach. The research was carried out in accordance with the Declaration of Helsinki, 2013, and approved by the bioethics committee of the Faculty of Rehabilitation Sciences, Andrés Bello University, document number A-053. Each participant signed an informed consent prior to their participation. In the case of participants under the age of 18 years, their parents or guardians signed the assent and the authorization.

Participants

Surfers and bodyboarders from the coastal towns of Reñaca and Concón in the Valparaíso Region, Chile, were invited to voluntarily participate in this study.

Inclusion and exclusion criteria

All volunteers who had more than one year of experience practicing the sports consistently on the central coast of Chile were included. Those who practiced regularly in other locations and countries were excluded, as well as those who had earwax blockages, a diagnosis of hereditary exostosis, or a history of previous bilateral canaloplasty.

A total of 103 volunteers agreed to participate in the study, of which 36 were excluded from the analysis according to the exclusion criteria. Specifically, 9 of them were excluded for presenting bilateral earwax plugs, 5 were excluded for being underage and not obtaining their parents' or guardians' consent, 12 of them for having been practicing sports consistently for less than one year, 3 for presenting hereditary EACE, 2 for having reported a history of surgery for EACE (canaloplasty), 1 for practicing in a different location, and 4 for not attending the video otoscopy. The final sample was made up of a total of 67 practitioners (134 ear canals), 53 men and 14 women, with an average age of 31.15 ± 12.25 years, and an average number of accumulated days in the water of 1,470.53 ± 2,146.52, a value that was obtained by multiplying the years of practice, by the number of days they practiced per week, by months of the year (see Table 2).

Table 2. Characteristics of the participants.

	Mean	SD	Mode	Max.	Min.
Age (years)	31.15	12.25	33	72	16
Years of Practice	9.21	7.49	5	41	1
Accumulated Days	1,470.53	2,146.52	720	13,776	48

SD: Standard deviation; Max.: Maximum observed value; Min.: Minimum observed value.

Procedure

Each participant was given a questionnaire that allowed them to identify their habits related to sports practice. Additionally, a simple otoscopy was performed to rule out the presence of an earwax blockage, which would hinder the diagnosis of EACE. Subsequently, the participants who did not present an earwax plug underwent a video otoscopy in order to determine the presence of EACE and its severity through direct observation. This was carried out by an ENT doctor.

Questionnaire

The questionnaire was used to gather epidemiological data on the habits of the participants. Specifically, it included questions such as the time (in years) that they had been practicing the sport, the frequency of their practice in days per week, and the months of the year in which they practice. This information was used to determine the cumulative time (in days) that they were exposed to water. The methodology used was the one reported in the study by Nakanishi et al. (2011), who created the Surfing Index to estimate the exposure of the ears to water. This index consists of multiplying the days per week, by the months per year, by the years of surfing practice. Furthermore, the questionnaire included an open question to ask about the use of ear protection, inquiring about the type of protection (cap, earplugs, or both), the time of use, and whether the use of protection was regular or not. Lastly, the participants were asked about auditory symptoms they have perceived as a result of practicing these water sports (see Figure 1).

Simple otoscopy and video otoscopy

The simple otoscopies were performed using a Riester® otoscope, while video otoscopies were carried out with Interacoustics® equipment. Both procedures were performed by a speech-language therapist. As already mentioned, the purpose of the simple otoscopy was to rule out the presence of earwax blockages, and the video otoscopy was performed to determine the presence and severity of EACE. To this end, an ENT doctor performed the direct observation of the video otoscopy for each of the participants. The Umeda classification was used to determine the severity of EACE (Umeda et al., 1989). This classification has been used in previous studies on surfers (Altuna Mariezkurrena et al., 2004; Kroon et al., 2002; Nakanishi et al., 2011; Wong et al., 1999) because it distinguishes between different degrees of EACE, expressing them in percentage of obstruction, from absence (0%), grade I or mild (<25%), moderate II and III (subdivided into moderate minus [-] (26-50%) and moderate plus [+] (51-75%), and grade IV or severe (> 76%) (see Table 3).

Statistical analysis

Once the data were obtained, they were tabulated using a Microsoft Office® 2013 Excel spreadsheet, in order to analyze them through descriptive statistics. The cases of EACE were

separated by laterality. This means that percentage, mean, standard deviation, and maximum and minimum values observed were determined for the left and right ears.

Surf and bodyboard practice questionnaire

Age: **____ Years**

Sex: **M – F**

Time (days - months - years) practicing the sport: _____

Time of the year in which you practice the sport more frequently:

_____

Number of days per week that you practice the sport:_____

Hours of practice per day:_____

Times during the day in which you practice the sport: **Morning – Afternoon – Both**

Location(s) in which you practice the sport:_____

Number of years practicing in said location:_____

Use of ear protection:

-Type:_____

- Uni o Bilateral:_____

-Time of use:_____

History of hereditary exostosis: **Yes – No**

Episodes of otitis: **Yes – No**

Hearing loss sensation: **Yes – No**

Sensation of ringing in the ears due to practicing the sport: **Yes – No**

Previous surgical interventions: **Yes – No**

Other: _____

Figure 1. Surf and bodyboard practice questionnaire.

Table 3. Classification of the EACE into categories, degrees, and percentages of obstruction.

Degrees of EACE				
Classification		Category	% EAC Obstruction	Image
Letters	Umeda			
A	I	Absence of EACE	0	
B	II	Mild	≤25	
C	III	Moderate (-)	26-50	
D	IV	Moderate (+)	51-75	
E	V	Severe	≥76	

RESULTS

Video otoscopy: Presence of EACE and degree of severity

Regarding the presence of EACE, 57 of the 67 volunteers evaluated (77.61% of the sample) presented some degree of exostosis, while only 15 of them showed an absence of EACE in both ears (see Figure 2). Of the 52 participants with EACE, 41 (61.2%) presented bilateral EACE and 11 (16.4%) unilateral EACE; 5 (7.5%) in the right ear, and 6 (8.9%) in the left ear. When analyzing the cases independently by ear, it was observed that 93 of the 134 ears (69.4%) presented some degree of EACE, with 46 of them (68%) showing signs of exostosis in the right ear and 47 (70.1%) in the left ear (see Table 4).

Table 4. Degrees of EACE severity in the right ear (AD) and left ear (AS).

Degree of EACE		AD EACE		AS EACE	
Letter	Number	n°	%	n°	%
A	0	21	33.33	20	30.43
B	I	19	27.53	23	33.33
C	II	14	20.28	9	14.49
D	III	4	5.79	8	11.59
E	IV	9	13.04	7	10.14
EACE Sum		67	100.0	67	100.0

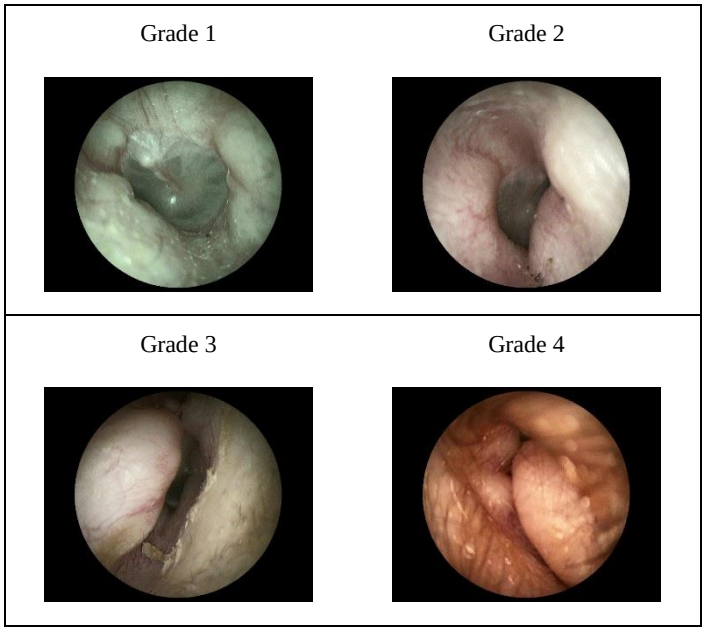

Figure 2. Examples of the different degrees of EACE observed in this study.

Prophylactic measures

Regarding protection measures, 41 of the 67 volunteers (61.19%) reported not using any type of protection, while 26 participants (38.8%) referred using some type of protection irregularly during their sports practice. Of those 26, 11 mentioned wearing earplugs bilaterally, 4 wore a cap and earplugs, and 11 wore a cap only. Regarding the presence of EACE, 31 of the 41 participants who did not use protection (75.6%) had developed EACE, while 21 of the 26 that used protection (80.7%) developed the condition (see Table 5).

Table 5. Use of ear protection and development of EACE.

Protection	EACE	No EACE	Total
Uses	21	5	26
Does not Use	31	10	41
Total	52	15	67

Auditory symptoms of the participants

Concerning the auditory symptoms reported by the surfers and bodyboarders in this study, the most frequent was the sensation of ear fullness, which was reported by 56.5% of the volunteers, followed by ringing or tinnitus, reported by 37.7 % of the participants and, in third place, a sensation of hearing loss, which was mentioned by 26.1% of the volunteers.

DISCUSSION

This study aimed to determine the prevalence and severity of EACE in surfers and bodyboarders from the southern coasts of the Pacific Ocean, where one of the coldest waters is found for practicing these sports. The prevalence of EACE in the central coast of Chile that was found in this study was 77.6%, with 61.2% being bilateral. In the cases where EACE was unilateral, a similar frequency was observed for the left and right ears. In addition, 62% of the participants reported not using ear protection.

It is noteworthy that the prevalence of EACE found in this research is similar to that observed in athletes from other coasts of the world. This is the case of Australia, where prevalences of 76% (Hurst et al., 2004) and 71.8% (Simas et al., 2021), have been reported; the United States, with a prevalence of 73.5% (Wong et al., 1999), and New Zealand, with a prevalence of 73% (Chaplin & Stewart, 1998). The incidence found in the present study has only been surpassed by the 80% prevalence of EACE in Japanese surfers, reported three decades ago by the team of Umeda et al. (1989), where the SST is similar to that of the coasts of central Chile.

It should be highlighted that the highest prevalences of EACE reported in the literature are found in southern latitudes, where the SST is similar to the temperature of the water off the coast of Valparaíso in the southern Pacific Ocean, albeit only in winter. This suggests that water temperature is a crucial factor in the development of EACE. It is particularly relevant that, on the coasts of Japan, reports show a decrease in the prevalence of EACE in surfers, from 80% in 1989 (Umeda et al., 1989) to 60% in 2011 (Nakanishi et al., 2011). Although the cause of this decrease is not clear, it should be noted that the entire population of professional surfers who participated in the study by Nakanishi et al. (2011) reported using ear protection, while in the study by Umeda et al. (1989), this information was unclear. The use of protection by Japanese surfers may have influenced the reduction in the prevalence of EACE. In this regard, a recent study by Lambert et al. (2021) shows that the use of earplugs prevents the development of EACE, compared to using a cap (Lambert et al., 2021). Considering that the SSTs of the coasts of Japan and central Chile are similar, an attempt could be made to reduce the prevalence of EACE by educating athletes who are exposed to cold waters about the proper use of ear protection.

We must emphasize that the use of prevention measures among the participants of this study was significantly low and inconsistent. This is noteworthy due to the evidence that the use of earplugs would be the most efficient method to insulate the ear canals from exposure to cold, thus managing to prevent the development of EACE (Lambert et al., 2021). A possible explanation for the low percentage of practitioners using protection is provided by Srinivasan et al. (2012), who mention that athletes refer that using ear protection affects their hearing, producing disturbances in spatial orientation. Thus, the high percentage of surfers who do not use protection in this study could be explained by fear of reducing their perception of the natural environmental sounds, which they use to orient themselves, or due to ignorance of the effects of using or not using protection while surfing.

Table 6. Ranking of the 10 countries with the highest published prevalences of EACE.

Ranking	% EACE	Country	Author	Year
1	80	Japan	Umeda et al.	1989
2	77.6	Chile	Orellana et al.	2022
3	76	AUS	Hurst et al.	2004
4	73.5	USA	Wong et al.	1999
5	73	NZ	Chaplin & Stewart	1998
6	71.8	AUS	Simas et al.	2021
7	66	Ireland	Lennon	2014
8	63.81	UK	Attlmayr & Smith	2015
9	63	USA	Kroon et al.	2002
10	61	Spain	Altuna et al.	2004

On the other hand, the high prevalence of EACE among people who reported using protection (75.6%), which is similar to that of those who did not use it (80.7%), is significant. This contradicts the results of the study by Lambert et al. (2021), who observed a lower prevalence of EACE in practitioners who used protection specifically designed for surfing. This difference could be explained by the inconsistent use of protection and the heterogeneity in the type of protection used by the participants of this study. It is therefore proposed that the high prevalence of EACE observed in the participants of this research who use protection does not necessarily contradict the aforementioned evidence, but rather invites us to offer educational interventions to this population, aimed at encouraging the correct use of ear protection.

In summary, there is a high prevalence of EACE in people who practice water sports, and the treatment for this condition is primarily surgical. On the other hand, the evidence shows that this high prevalence could be reduced by increasing the use of ear protection. It is for this reason that we consider it fundamental to educate this population about existing prophylactic measures. Specifically, it is crucial to insist on the use of hearing protection that insulates ears from the cold as a way to prevent the main triggering factor of EACE, but one that also provides mechanical support to prevent the growth of bone tissue in the external auditory canal. It seems that the use of earplugs could meet both objectives: insulating the ears from the cold and providing mechanical support to prevent bone growth. Furthermore, earplugs are an accessible and economical option to be implemented as a prophylactic measure (Lambert et al., 2021; Lobo, 2015; Reddy et al., 2011). Future studies should focus on demonstrating the role and differences in the use of ear protection measures for the prevention of exostosis.

CONCLUSION

A high prevalence of EACE was found in surfers and bodyboarders from the coasts of the southern Pacific Ocean who participated in this study. This is the first report about the prevalence of EACE in athletes who practice these sports systematically in one of the coldest waters of the Pacific Ocean. These findings invite us to familiarize ourselves with the prevalence of this health condition in people who practice water sports, in order to offer preventive recommendations for this population.

ACKNOWLEDGMENTS

We would like to thank all the people who contributed to the completion of this study, especially the students (now colleagues), speech-language therapists Piera Zumelzu, Karina Bustamante, Catherine Adames, and Fernanda Díaz, for their excellent disposition and contribution to the collection of data for this study. Additionally, we deeply thank those who voluntarily participated as subjects of this research.

REFERENCES

Altuna Mariezkurrena, X., Gómez Suárez, J., Luqui Albisua, I., Vea Orte, J. C., & Algaba Guimerá, J. (2004). Prevalencia de exóstosis entre surfistas de la costa guipuzcoana. *Acta Otorrinolaringológica Española*, *55*(8), 364–368.

https://doi.org/10.1016/S0001-6519(04)78537-4

Altuna Mariezkurrena, X., Vea Orte, J. C., Camacho Arrioaga, J. J., Algaba Guimerá, J., Altuna Mariezkurrena, X., & Algaba Guimerá, J. (2006). Tratamiento quirúrgico de las exóstosis de conducto auditivo externo. *Acta Otorrinolaringológica Española*, *57*(6), 257–261. https://doi.org/10.1016/S0001-6519(06)78704-0

Attlmayr, B., & Smith, I. M. (2015). Prevalence of 'surfer's ear' in Cornish surfers. *The Journal of Laryngology & Otology*, *129*(5), 440–444. https://doi.org/10.1017/S0022215115000316

Azizi, M. H. (2011). Ear disorders in scuba divers. *The International Journal of Occupational and Environmental Medicine*, *2*(1), 20–26.

Chaplin, J. M., & Stewart, I. A. (1998). The prevalence of exostoses in the external auditory meatus of surfers. *Clinical Otolaryngology & Allied Sciences*, *23*(4), 326–330. https://doi.org/10.1046/j.1365-2273.1998.00151.x

Chen, D., Zhao, M., & Mundy, G. R. (2004). Bone Morphogenetic Proteins. *Growth Factors*, *22*(4), 233–241. https://doi.org/10.1080/08977190412331279890

Cooper, A., Tong, R., Neil, R., Owens, D., & Tomkinson, A. (2010). External auditory canal exostoses in white water kayakers. *British Journal of Sports Medicine*, *44*(2), 144–147. https://doi.org/10.1136/bjsm.2008.048157

Hurst, W., Bailey, M., & Hurst, B. (2004). Prevalence of external auditory canal exostoses in Australian surfboard riders. *The Journal of Laryngology & Otology*, *118*(5), 348–351. https://doi.org/10.1258/002221504323086525

Kroon, D. F., Lawson, M. L., Derkay, C. S., Hoffmann, K., & McCook, J. (2002). Surfer's Ear: External Auditory Exostoses are More Prevalent in Cold Water Surfers. *Otolaryngology–Head and Neck Surgery*, *126*(5), 499–504. https://doi.org/10.1067/mhn.2002.124474

Lambert, C., Marin, S., Esvan, M., & Godey, B. (2021). Impact of ear protection on occurrence of exostosis in surfers: An observational prospective study of 242 ears. *European Archives of Oto-Rhino-Laryngology*, *278*(12), 4775–4781. https://doi.org/10.1007/s00405-021-06609-8

Landefeld, K., Bart, R. M., Lau, H., & Cooper, J. S. (2022). Surfer's Ear. En *StatPearls [Internet]*. StatPearls Publishing. https://www.ncbi.nlm.nih.gov/books/NBK534874/

Lennon, P., Murphy, C., Fennessy, B., & Hughes, J. P. (2016). Auditory canal exostoses in Irish surfers. *Irish Journal of Medical Science (1971 -)*, *185*(1), 183–187. https://doi.org/10.1007/s11845-015-1265-x

Lobo, D. R. (2015). Exostoses of the external auditory canal. *World Journal of Otorhinolaryngology*, *5*(1), 14–20. https://doi.org/10.5319/wjo.v5.i1.14

Moore, R. D., Schuman, T. A., Scott, T. A., Mann, S. E., Davidson, M. A., & Labadie, R. F. (2010). Exostoses of the external auditory canal in white-water kayakers. *The Laryngoscope*, *120*(3), 582–590. https://doi.org/10.1002/lary.20781

Nakanishi, H., Tono, T., & Kawano, H. (2011). Incidence of External Auditory Canal Exostoses in Competitive Surfers in Japan. *Otolaryngology–Head and Neck Surgery*, *145*(1), 80–85. https://doi.org/10.1177/0194599811402041

Reddy, V. M., Abdelrahman, T., Lau, A., & Flanagan, P. M. (2011). Surfers' awareness of the preventability of 'surfer's ear' and use of water precautions. *The Journal of Laryngology & Otology*, *125*(6), 551–553. https://doi.org/10.1017/S0022215111000041

Sato, M., Ochi, T., Nakase, T., Hirota, S., Kitamura, Y., Nomura, S., & Yasui, N. (1999). Mechanical Tension-Stress Induces Expression of Bone Morphogenetic Protein (BMP)-2 and BMP-4, but Not BMP-6, BMP-7, and GDF-5 mRNA, During Distraction Osteogenesis. *Journal of Bone and Mineral Research*, *14*(7), 1084–1095. https://doi.org/10.1359/jbmr.1999.14.7.1084

Simas, V., Furness, J., Hing, W., Pope, R., Walsh, J., & Climstein, M. (2016). Ear discomfort in a competitive surfer. *Australian Family Physician*, *45*(9), 644–646.

Simas, V., Hing, W., Rathbone, E., Pope, R., & Climstein, M. (2021). Auditory exostosis in Australian warm water surfers: A cross-sectional study. *BMC Sports Science, Medicine and Rehabilitation*, *13*(1), 52. https://doi.org/10.1186/s13102-021-00281-5

Simas, V., Remnant, D., Furness, J., Bacon, C. J., Moran, R. W., Hing, W. A., Climstein, M., Simas, V., Remnant, D., Furness, J., Bacon, C. J., Moran, R. W., Hing, W. A., & Climstein, M. (2019). Lifetime prevalence of exostoses in New Zealand surfers. *Journal of Primary Health Care*, *11*(1), 47–53. https://doi.org/10.1071/HC18097

Srinivasan, J., Reddy, V. M., & Flanagan, P. M. (2012). Audiological implications of earplugs used for the prevention of aural exostoses. *European Archives of Oto-Rhino-Laryngology*, *269*(3), 787–790. https://doi.org/10.1007/s00405-011-1730-8

Umeda, Y., Nakajima, M., & Yoshioka, H. (1989). Surfer's ear in Japan. *The Laryngoscope*, *99*(6), 639–641. https://doi.org/10.1288/00005537-198906000-00012

Wegener, F., Wegner, M., & Weiss, N. M. (2022). External auditory exostoses in wind-dependent water sports participants: German wind- and kitesurfers. *European Archives of Oto-Rhino-Laryngology*, *279*(5), 2353–2361. https://doi.org/10.1007/s00405-021-06939-7

Wong, B. J. F., Cervantes, W., Doyle, K. J., Karamzadeh, A. M., Boys, P., Brauel, G., & Mushtaq, E. (1999). Prevalence of External Auditory Canal Exostoses in Surfers. *Archives of Otolaryngology–Head & Neck Surgery*, *125*(9), 969–972. https://doi.org/10.1001/archotol.125.9.969