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Original Article

Tinnitus and leisure noise*

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The British Society of Audiology

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Abstract

Objective: To study the relationship of life-time noise exposure and experience of tinnitus. *Design:* Audiometric measures included otoscopy, pure tone air- and bone-conduction hearing threshold levels (HTL) and otoacoustic emissions (OAEs). Participants completed questionnaires including demographic information, past hearing health, history of participation in loud leisure activities, and attitudes to noise. *Study sample*: A representative sample (1435) of the young (11–35 years old) Australian population. *Results:* Of the sample, 63% indicated they experienced tinnitus in some form. There was no correlation of tinnitus experience with HTL or OAE amplitudes. Although median octave band HTLs for those who experienced tinnitus ''all the time'' were slightly higher for those who did not, neither group exhibited HTLs outside clinically-normal values. Of those who experienced tinnitus a direct correlation was found between frequency of experience of tinnitus and increasing cumulative, life-time noise exposure. Those who experienced tinnitus were more likely to report noticing deterioration in their hearing ability over time and to report difficulty hearing in quiet and/or noisy situations. *Conclusions*: Experience of tinnitus was found throughout this young population but not associated with HTLs or variation in OAE amplitudes. Males experienced 'permanent' tinnitus at significantly greater rate than females.

Key Words: Tinnitus; leisure noise exposure; adolescents; young adults; hearing health

Introduction

Tinnitus has been described as ''one of the most challenging symptoms in otology'' (Sataloff & Sataloff, 1987, p. 397) and defined in various ways. In this paper, tinnitus refers to ''the experience of relatively audible noise in the ears or head but with no identifiable external source'' (Noble, 1998, p. 144). In the survey described in this article tinnitus was defined for participants as ''ringing, buzzing or other sounds in your ears or head''. Estimating the incidence of tinnitus across the general population is a difficult task requiring large samples across all age groups. A brief review of previous studies, in which participants were in a similar age range to those of the current study (11–35 years), follows.

The US 1999–2004 National Health and Nutritional Examination Surveys (NHANES) (Shargorodsky et al, 2015) reported on the prevalence of tinnitus for 14,178 participants with the results weighted so as to be representative of the US population. The prevalence rate of tinnitus for males and females combined, described as ''any'' or ''frequent'', was reported to be 20.2% and 2.6%, respectively for under 30 years old and 21.6% and 4.1% for 30–39 year olds. It was concluded that a ''history of leisure-time, occupational and firearm noise exposure were all associated with increased odds of tinnitus [experience]'' (p. 715).

A Belgian study of 3892 high school students (mean age =16.6 years, males and females) reported that 18.3% experienced ''permanent'' tinnitus and 74.9% ''temporary'' tinnitus (Gilles et al, 2013). A similar study of university students (19 to 26 years, $n = 145$, male and female) found 14.8% reported ''permanent'' tinnitus and 89.5% had experienced tinnitus ''at least once after being exposed to loud music'' (Gilles et al, 2012, p. 3).

In another US study, of the perceived hearing status and attitudes toward noise of young adults (18–27 years, $n = 245$), it was reported that 13.5% experienced ''prolonged'' tinnitus (determined as lasting for greater than 24 h), while 27% reported never having tinnitus (Holmes et al, 2007). Over ''20% of the participants reported having some hearing loss symptoms [including but not limited to tinnitus] after noise exposure 'at least sometimes''' (p. S185).

A Swedish survey of 1285 high-school students reported that 8.7% experienced ''permanent'' tinnitus. These data were also presented in two sub-sets, upper secondary school (16–19 years) and secondary school (13–15 years) where 10.3% and 6.8%,

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respectively, reported ''permanent'' tinnitus (Olsen-Widen & Erlandsson, 2004).

A Finnish study of 405 teenagers (12–17 years, males and females) reported 80% of 15–17 year olds, and 65% of 12–13 year olds had experienced tinnitus at some time. Of the total number, 2.5% experienced tinnitus ''often'', 69.6% ''sometimes'' and 27.9% ''never'' (Jokitulppo et al, 1997). This study also made an estimation of the weekly noise exposure of participants, and determined that the ''incidence of hearing symptoms [including tinnitus] seemed to be correlated to increased noise dose'' (p. 258), however, no specific noise exposure figures were provided. Interestingly, 59.2% of the participants indicated that they had experienced ''pain in the ears [undefined] associated with loud noise'' (p. 37).

The current study was part of a much larger project designed to examine any relationship(s) between the exposure of young Australians to leisure noise and hearing health indicators (Carter, 2011). The comprehensive methodology involved provided an opportunity for the relationship(s) between self-reported experiences of tinnitus and cumulative, life-time noise exposure from leisure activities to be examined in a large, well defined cohort for whom relevant health history and detailed audiometric data were available. The (on-line) reference Carter (2011) provides further background to the study and detailed copies of the questionnaires used.

Methods

Study sample

A sample of the Australian population aged from 11 to 35 years old was recruited from various organisations including: high schools, universities, tertiary and further education colleges and a variety of workplaces within New South Wales. Organisations were contacted on an ad hoc basis and, after the aims of the study were explained, invited to participate. Participating organisations were from in a diverse range of areas including city; greater metropolitan and rural locations, in an attempt to gather participants from a wide range of occupational, socio-economic and demographic backgrounds. Individuals within participating organisations were informed of the study by email, notices in newsletters, circulars and bulletin boards, in regular use by the organisation. Parents of high school students were provided with information and a personalised written invitation for their child to participate. The only requirements for participation were being within the required age range and providing informed consent.

Participants completed a comprehensive hearing health history, attitudes and behaviour (regarding noise exposure) questionnaire, with an emphasis on leisure participation likely to have involved significant noise. This included but was not limited to: attendance at dance clubs, concerts and loud music events; personal stereo use; playing a musical instrument; participation in bands or orchestras; firearm use; motor sport participation; and any workplace noise exposure. The survey was completed either in paper or on-line form prior to attendance at an audiometric assessment appointment. Of those who provided audiological data ($n = 1435$), 74% (1059) provided questionnaire data, including tinnitus information. During the audiological appointment questions in relation to current hearing health status and recent noise exposure were asked Seven hundred and twenty three participants (mainly high school students) were also questioned about tinnitus, music listening behaviour and knowledge of hearing health principles.

The full details of the HTLs and otoacoustic emissions (OAEs) of this group have been published previously (Williams et al, 2014; Carter et al, 2015).

Survey questions

The specific questions on tinnitus asked in this survey are presented in Appendix A.

Audiometric testing

All tests were carried out by tertiary qualified, professional audiologists. All audiometric testing was carried out on-location at each participating school, college or workplace. Prior to audiometric testing, an otoscopic examination was carried out to exclude occluded ear canals or other irregularities. A comprehensive description of all audiometric tests carried out has been presented in detail previously (Carter, 2011; Williams et al, 2014).

Audiometric tests included: otoscopy; air-conduction audiometry (500, 1000, 2000, 4000, 6000 and 8000 Hz); bone-conduction audiometry (500, 1000, 2000 and 4000 Hz) (masking used if required) and tympanometry. The audiometric test conditions met the requirements of International Standards (ISO 8253-1:2010) for measuring to a minimum 0 dB HTL with an uncertainty of +5 dB. This was managed by choosing the quietest, appropriate available location at the test site and the use of insert earphones covered by a noise-excluding headset (Fisher & Williams, 2013). Ambient noise conditions were sampled throughout the test sessions and any results obtained during non-compliant conditions were excluded from the analysis.

Both distortion product (DPOAE) and transient evoked TEOAE) were measured. For DPOAEs two protocols including amplitude and signal-to-noise (SNR) parameters were measured in bands with centre frequencies 1.5, 2.5, 3, 5, 6 and 8 kHz. For TEOAEs reproducibility, amplitude and SNR were measured at centre frequencies 1, 1.4, 2, 2.8 and 4 kHz. As there are no existing OAE normative values available for comparison purposes no OAE results are included in this discussion but, as noted above, are fully reported elsewhere (Carter et al, 2015).

Estimation of life-time noise exposure

Over many years National Acoustic Laboratories (NAL) has developed research tools capable of evaluating an individual's cumulative life-time noise exposure on the basis of their reported history of participation in noisy activities (Williams et al, 2010; ISO, 1999, 2013). This is, in essence, an extension of the technique employed by International Standard ISO (1999, 2010) for calculating the daily A-weighted sound exposure, $E_{A,8h}$. This involves the summation of exposures from multiple sources including all significant exposures over the life time (Williams, 2011). For simplicity, cumulative exposure is presented in units of Pascal squared hours (Pa^2h) rather than Pascal squared seconds (Pa^2s). This procedure therefore provides the value of an eight hour continuous A-weighted noise exposure of 85 dB being 1.01 Pa^2h rather than 3.64 kPa^2s.

The value 1.01 Pa^2h is significant as it is the defined action level, or ''Exposure Standard'', for exposure to continuous workplace noise in many Workplace Health and Safety jurisdictions around the world (I-INCE, 1997). As such, it conveniently represents a familiar indication of the relative risk of hearing loss, or noise injury, for the

noise exposed individual. The figure of 1 Pa^2h represents what can be considered as an ''acceptable daily exposure'' (i.e. exposure below an accepted level of risk). While this does not represent a zero risk situation, it represents what has been generally agreed as an acceptable level of risk of exposure in the industrial context as regards health and safety.

The situation specific noise-level data used in estimating whole-of-life noise exposure for participants in this study were previously obtained using personal noise dosimetry as specified by combined ''Australian/New Zealand Standard AS/NZS 1269.1 2005 Occupational noise management Part 1: measurement and assessment of noise immission and exposure'' (Standards Australia, 2005). This methodology has been used extensively by NAL for establishing noise exposures during non-work and leisure noise activities, where it is otherwise difficult to carry out noise surveys or other more conventional procedures (Australian Hearing, 2008; Beach et al, 2013a; Gilliver et al, 2013). The procedure is particularly useful for ''high risk'' activities.

Data analysis and ethics

All statistical tests and calculations were carried out using Microsoft Excel® 2010 and Statistica® Version 10 (StataCorp, College Station, TX). Sample comparisons were made using two sample *t*-tests and regression analysis assuming a normal distribution of results, HTL was used as the predictor variable and incidence of tinnitus as the dependent variable. In keeping with the accepted protocol (ISO 7029, 2000) HTLs are presented as median values. As with any questionnaire, not every respondent consistently answered every question, hence participant numbers vary slightly between items.

Ethics approval for this project was provided by the Australian Hearing Human Research Ethics committee and, with respect to work in schools, the NSW Department of Education and Training – Student Engagement and Programme Evaluation Bureau. Individual participation was not rewarded apart from the receipt of a comprehensive hearing test report. However, a donation was made to a charity selected by the participating organisation, in the name of that organisation, as an incentive to participation.

Results

There were 1359 responses to the question ''Have you ever had tinnitus? [No; Yes, sometimes; Yes, often; Yes, all the time''] of which 503 (37%) said ''No'' and 856 (63%) said ''Yes''. In respect to frequency of experiencing tinnitus, of those who indicated they had experienced tinnitus, 751 (55.3%) said ''Yes, sometimes'', 69 (5.1%) ''Yes, often'' and 36 (2.7%) ''Yes, always present''.

Analysis using linear regression, found no statistically significant difference(s) (i.e. $p < 0.05$) between the pure tone hearing thresholds (by frequency) of those who experienced tinnitus and those who did not. Again using linear regression analysis, no statistically significant correlations between any of the measured OAE parameters and reported experience of tinnitus were found. These results are summarised in Table 1.

Table 1 also presents the mean and median values of cumulative life exposure with respect to the experience of tinnitus. Median values were included to demonstrate the influence of a few extreme outliers.

Statistically (t-test), there was no significant difference between the estimated cumulative noise exposure levels for males or females. The mean exposure for females was 3.11 kPa^2h (SD = 7.33) and for males 2.90 kPa^2h (SD 5.27, $p = 0.596$). The mean exposure for combined males and females was 2.99 kPa^2h (SD = 0.44) with a median of 0.77 kPa^2h. Hearing thresholds (median values) for the study population are presented in Table 2.

A relationship between the median cumulative life-time exposure and the experience of tinnitus for the four frequency reporting values of ''No'', ''Sometimes'', ''Often'' and ''All the time'' was observed. This relationship is demonstrated in Figure 1 (''No'' = 1; ''Sometimes'' = 2; ''Often'' = 3; and ''All the time'' = 4) as a line of best fit for median exposure levels. It shows an increase in the reported frequency (i.e. persistence) of tinnitus with increasing mean cumulative exposure. The average age of those who experienced tinnitus ''all the time'' was 27.8 years (SD =6.8) and the median age was 29.4 years. The youngest person who indicated tinnitus ''all the time'' was a 16.5 year old male. There was also no significant correlation by linear regression ($p < 0.05$) between age and experience of tinnitus at any frequency. Males outnumbered females for tinnitus ''all the time'' with respective numbers of 22 (61%) to 14 (39%). Both a Chi-square test and a Test of Proportions show a statistically significant difference between males and females for tinnitus ''all the time'', with similar ''*p*'' values of 0.0089.

Table 3 summarises the duration of reported tinnitus episodes in relation to how often tinnitus occurs – i.e. ''How long does the tinnitus usually last?: < one minute; a few minutes; up to an hour; hours – days; always present'' and ''Have you ever had tinnitus? No; Yes, sometimes; Yes, often; Yes all the time.''

Adult participants were asked the question: ''Over time have you noticed any change in your hearing ability?'' to which 675 responded, 399 ''No'' and 276 ''Yes''. Of the 276 who had noticed a change in their hearing, 220 (80%) indicated they experienced tinnitus; of the 399 who had not noticed a change in hearing, 238 (57%) also experienced tinnitus. This result indicates that tinnitus is not necessarily directly associated with a perceptible change in hearing status.

Note: As also noted in conjunction with Table 3, six participants responded ''Yes, all the time'' to the question ''Have you ever had tinnitus? (i.e. ringing, buzzing or other sounds in your ears or head), No; Yes – sometimes; Yes – often; Yes, all the time'' but then did not respond to the subsequent question, viz ''How long does the tinnitus usually last? [1) < one minute; 2) A few minutes; 3) Up to an hour; 4) Hours to days; 5) Always present]''. These six participants were combined with those who responded ''Always present''.

Using linear regression models there were no significant correlations found between life-time, cumulative noise exposure and HTLs or otoacoustic emission parameters.

Discussion

When comparing the results of this tinnitus survey with previous surveys, the variation in wording of the questions asked in each study must be taken into account. It should also be considered that the interpretation of a given question may vary among participants, even when the questions are identically worded. This later point may be of particular importance when study populations significantly differ geographically and/or culturally, even when the preferred language is common. As noted, the leading question asked in this survey was ''Have you ever had tinnitus?

Table 1. Hearing threshold values (median) (dB) in relation to experience of tinnitus.

		Median left/right hearing threshold level (dB) at frequency (Hz)						
Have you ever had tinnitus?	*Sample* n	*500*	*1000*	*2000*	*3000*	*4000*	*6000*	*8000*
No	503	5/5	5/5	5/5	5/5	5/5	5/5	5/5
Yes, sometimes	751	10/5	5/5	5/5	5/5	5/5	5/5	5/5
Yes, often	60	10/5	5/5	5/5	5/5	5/5	5/5	5/5
Yes, all the time	36	10/10	5/10	5/5	10/10	7.5/5	10/5	5/5
Did not respond	61	5/5	5/5	5/5	5/5	5/5	5/5	5/5
Total	1420							

(i.e. 'ringing', 'buzzing', or other sounds in your ears or head)?'' While this may appear to be an unambiguous question, to someone who has never consciously thought about the experience of tinnitus it may be open to wide interpretation, and the variation between participant perspectives may be considerable.

As noted previously in the US NHANES study (Shargorodsky et al, 2015), in response to the question category ''Any tinnitus'', 20.2% of under 30 year olds and 21.6% of 30 to 39 year olds responded positively. For ''Frequent Tinnitus'' (at least once daily) responses for the two age groups were 2.6% and 4.1%, respectively. In the current study results for tinnitus ''Sometimes'' and ''Often'' were 55% and 5%, respectively.

In the Belgian high school student study (Gilles et al, 2013), (mean age = 16.6 years), 18.3% reported ''permanent'' tinnitus compared with only 3% reporting constant (all the time) tinnitus in the current study. It is possible that the concepts ''permanent'' and ''constant'' were not identically interpreted by the two study cohorts, which may account for this difference in outcomes. However, 74.9% reported ''temporary'' tinnitus in the Belgian study, which is a similar outcome to the summation of tinnitus categories ''sometimes'' and ''often'' in the current study at 60%. In the second Belgian study (Gilles et al, 2012), 14.8% reported ''permanent'' tinnitus. These results are again well above the findings of the current study where 3% experienced ''constant'' tinnitus and 63% reported any tinnitus (any frequency/duration). In the Swedish study (Olsen-Widen & Erlandsson, 2004), 8.7% of 1285 high school students reported permanent tinnitus (10.3% in 16–19 year olds and 6.8% in 13–15 year olds) which is also greater than the 3% observed in the current study. While the reasons for this discrepancy are unclear, it is again possible that variability in the interpretation of questions/differences in response choices between cohorts may have influenced outcomes.

For the Florida study (Holmes et al, 2007) ''prolonged'' tinnitus was reported by 13.5%, which is comparable to the 12% of the current study reporting tinnitus in the combined ''often'' and ''all the time''. In the present study, the question structure made it clear that 3% of respondents experienced tinnitus constantly, however the indicator ''permanent'' tinnitus may not necessarily capture the frequency of tinnitus experiences. The lack of experience of tinnitus is probably easier to capture unambiguously in survey terms than the actual experience of tinnitus. The Florida study also found that 27% of the 18–27 year olds questioned reported never having tinnitus. This is a similar order of magnitude to current study results of 37%.

In the earlier Finnish study of 405 teenagers (12–17 year olds), 65% of the 12–13 year olds and 80% of the 15–17 year olds reported experiencing tinnitus – this can be meaningfully compared to the combined ''sometimes'', ''often'', ''all the time'' response categories in the current study, age range 11–35 years, for which 63% gave a positive response. Among the Finnish teens 2.5% reported tinnitus often, 69.6% sometimes and 27.9% never compared with 5% (often), 55% (sometimes) and 37% (never) in the current investigation, indicating similarity between the Finnish and Australian findings.

Table 2. Responses to the question ''Have you ever had tinnitus?'' including mean and median cumulative life-time noise exposures.

''Have you ever had tinnitus?'' (i.e. ''ringing buzzing, or other sounds in your ears'')	*Number*	*Cumulative life exposure estimate (kPa^2h)*	
		Mean (SD)	*Median*
Did not respond	61 (out of 1420)	–	–
No	530 (37%)	1.91 (3.87)	0.49
Yes	856 (63%)	–	–
Yes, sometimes	751 (55%)	3.64 (7.69)	1.02
Yes, often	69 (5%)	3.44 (5.08)	1.52
Yes, all the time	36 (3%)	6.48 (13.05)	2.25

The results in the current work were closely mirrored in an on-line survey of exposure to loud leisure noise activities conducted by the NAL study (Beach et al, 2013b). In the on-line NAL study, individuals were asked about their participation in high-noise leisure activities and symptoms of hearing damage. Responses to tinnitus questions indicated experience of tinnitus at: 30% ''never''; 37% ''occasionally''; 18% ''sometimes''; 4% ''often''; and 2% ''always'' (9% of survey respondents who selected an 'unsure' category for this question were excluded from further analysis). If the ''occasionally'' and ''sometimes'' categories of the Beach et al. study are combined the resulting 55% response rate mirrors that of the current study (see Table 4). Both the study by Beach et al (2013b) and the current study, are different samples of the overall Australian population so close agreement would be expected. The closeness of the findings indicates convergent validity (i.e. triangulation) of the survey instruments used in the research.

Overall while similarities between reported tinnitus occurrences can be seen between studies there are also variations. Because of the differences in methodology previously discussed, inconsistencies between findings do not necessarily indicate studies are contradictory, but make it difficult to draw definitive overall conclusions about the incidence of tinnitus among various populations. Table 4 presents a simplified comparison of results from the literature with those of the current study. Where the terminology in the question presented differed from the current study a note is included in the table.

Three of the studies included in Table 4 also investigated noise exposure in relation to experienced tinnitus. The Belgian studies

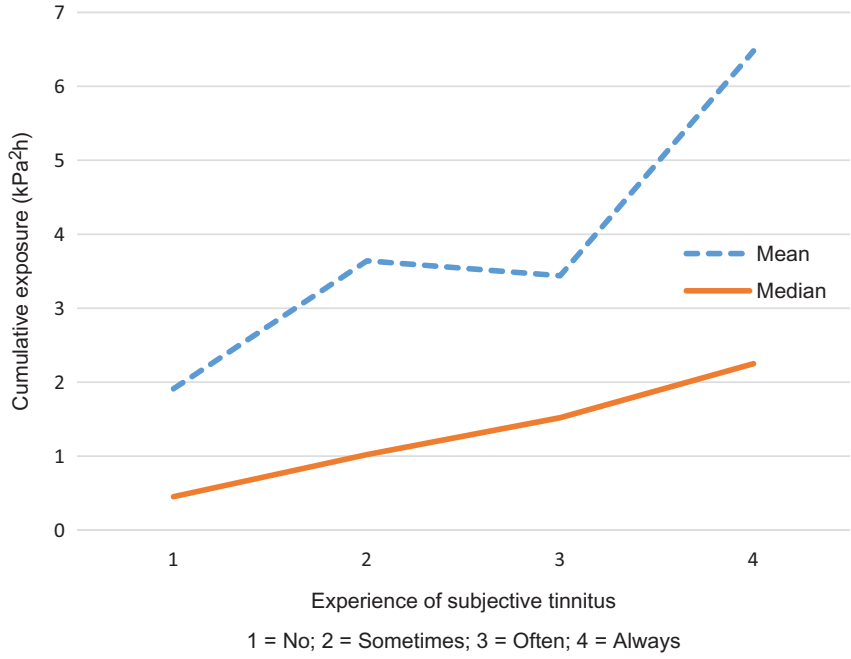

Figure 1. Cumulative life-time noise exposure in relation to the subjective experience of tinnitus for both mean and median exposures.

Table 3. The relation of frequency of experience of tinnitus to the duration of the tinnitus.

	How long does the tinnitus usually last?					
Have you ever had tinnitus?	*<than one minute*	*A few minutes*	*Up to an hour*	*Hours – days*	*Always present*	*Totals*
Yes, sometimes	207 (27%)	237 (31%)	111 (14%)	111 (14%)	6* (1%)	672 (87%)
Yes, often	8 (1%)	22 (3%)	11 (1%)	11 (1%)	12 (2%)	64 (8%)
Yes, all the time	–	–	–	–	30* (4%)	30 (4%)
Totals	215 (28%)	259 (34%)	122 (16%)	122 (16%)	48 (6%)	766 (100%)

Note: Six participants under the question ''Have you ever had tinnitus?'', marked both responses ''Yes, sometimes'' and then ''did not responds'' ''Always present'' for the question ''How long does the tinnitus usually last?''. For analysis these two sets of responses were regarded as tinnitus being present all of the time.

(Gilles et al, 2013), asked about participation in noisy leisure activities by university students but did not relate responses directly to tinnitus symptoms. The Swedish (Olsen-Widen & Erlandsson, 2004) investigation found that attendance at louder activities such as discotheques and concerts, was associated with more aggressive tinnitus symptoms compared with reported restriction to quieter activities, such as attending the cinema or school. The most detailed questioning of noise exposure was included in the 1997 Finnish study, where estimated weekly noise exposures were compared to ''the commonly used 85 dBA [sic] risk limit for hearing handicap'' (Jokitulppo et al, 1997). This procedure estimated the weekly leisure noise exposure and compared this to the exposure limit of an A-weighted 85 dB for an eight hour work day, extended to a five day exposure of 40 h, as a weekly ''risk limit'' (p. 258). Both the Florida (Holmes et al, 2007) and the Belgian high school student (Gilles et al, 2012) studies examined participation in noisy activities but did not attempt to quantify estimated exposures from the activities, except in the sense that that participation in noisy activities was observed to be generally more closely associated with the incidence of tinnitus than when participation was restricted to less noisy activities.

The observation in the current study that males showed a significantly higher incidence of experiencing tinnitus ''all the time'' compared to females may be an important issue to review in future studies. Without further data it can only be speculated as to whether this gender difference may relate to behavioural, vocational, social or physiological differences.

The current study is the first to attempt to relate the experience of tinnitus to an estimation of the whole-of-life noise exposure. The results show the majority of participants (63%) have experienced tinnitus, with frequency ranging from ''sometimes'' (55%), through ''often'' (5%), to ''all the time'' (i.e. constant) (3%). Table 2 reveals that the median hearing threshold levels (HTL) for those who experience tinnitus are well within the range considered to be clinically ''normal'' for individuals in the target age group (ISO 7029, 2000). Additionally, of those reporting experience of tinnitus, around 80% indicated that they had noticed a change in their hearing ability over time, with over 70% reporting difficulty hearing in quiet or noisy conditions. Reports, ''noticing a change in hearing over time'' and ''difficulty with hearing in noisy situations'', may represent important early indicators of noise injury, preceding significant, measurable shifts in pure tone HTLs.

Table 4. Comparison of current results with comparative studies from the literature.

Study	*Age (years)*	*Subject numbers*	*Experience of tinnitus*			
			Never	*Sometimes*	*Often*	*All-the-time*
Current	13–35	~1432	37%	55%	5%	3%
				63% (any)		
Beach et al (2013b)	18–35	1000	30% (+9% unsure)	37% (occasionally) 18% (sometimes)	4%	2%
				61% (any)		
Shargorodsky et al (2010) (NHANES)	Less than 30	~14,000 scaled as proportion of US population	–	20.2% (any)		
			–	–	2.6% (frequent)	
	30–39		–	21.6% (any)		
			–	–	4.1% (frequent)	
Gilles et al (2013)	Mean =16.6 (SD =1.29)	3892	–	74.9% (temporary)		18.3% (permanent)
Gilles et al (2012)	19–26	145	–	89.5% (transient)		14.8% (permanent)
Holmes et al (2007)	18–27 Mean =20.25	245	27%		13.5% (prolonged)	
Olsen-Widen & Erlandsson (2004)	13–19	~1285	–	–	8.7% (permanent)	
	13–15	~574	–	–	6.8% (permanent)	
	16–19	~680	–	–	10.3% (permanent)	

Where questions presented differed from the current study an indication of past terminology in also included.

As noted, no correlations were found between the experience of tinnitus and HTLs or OAEs. The frequency of tinnitus experience did, however, show a direct correlation with increasing cumulative, median noise exposure (see Figure 1).

The fact that a majority of participants (63%) of this study had some experience of tinnitus that was shown to increase in frequency with increased cumulative noise exposure agrees with the results of studies discussed (Jokitulppo et al, 1997; Olsen-Widen & Erlandsson, 2004; Beach et al, 2013b) that the ''incidence of hearing symptoms seemed to be correlated to increased noise dose'' (Jokitulppo et al, 1997, p. 257).

A relationship between noise exposure and/or attendance at ''loud events'' and the experience of tinnitus in the wider community has previously been acknowledged (Jokitulppo et al, 1997; Olsen-Widen & Erlandsson, 2004; Beach et al, 2013b). Figure 1 illustrates that tinnitus was also experienced by many participants in the current study who had reported relatively low levels of cumulative noise exposure. The personal experience of tinnitus after attending noisy events may be a major facilitator for raising the awareness of hearing health risks and may provide a personal and tangible catalyst for preventative action. This is particularly important, given the evidence that in the 11–35 year old cohort examined in this research, no significant impacts of noise exposure on HTLs were evident. Counselling about the risks of leisure-noise exposure in terms of the threat of hearing threshold shift is therefore intangible, compared with the immediate and salient experience of tinnitus many young people apparently experience.

Limitations

As for all studies relying on questionnaires, the resulting data relies on accurate and consistent responses from all participants. It is possible that some degree of recall bias may have affected these findings which introduces uncertainty in the estimation of cumulative noise exposure. The methodology used here, however, has been confirmed in earlier studies (Williams et al, 2010; Williams, 2011; Beach et al, 2013b). Furthermore, if there is some uncertainty in this regard it is applied equally across all participants without bias. The current data should be usefully valid, at least to a first approximation.

Conclusions

This was the first study to attempt an estimation of the whole-of-life, cumulative noise exposure from leisure noise amongst young Australians and relate this to tinnitus experience. The frequency of experience of tinnitus has been clearly demonstrated to be widespread in this population and shows a strong relation to the median cumulative, life-time noise exposure to noise from leisure activities. No correlation was found between life-time, cumulative leisure noise exposure and pure-tone HTLs or common otoacoustic emission parameters. Males were found to have a significantly higher incidence of constant tinnitus compared to females.

Given the tangible nature of tinnitus experience, hearing health education messages that associate tinnitus with noise-injury risk may be more compelling than those highlighting the threat of HTL shift.

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Appendix A1.

Specific questions asked for this study concerning hearing and experience of tinnitus 2.

Q. Do you generally have trouble hearing?:

(a) In quiet situations? No; A little; A lot;
(b) In noisy situations? No; A little; A lot;
(c) In classes or lectures? No; A little; A lot.

Q. Over time, have you noticed any change in your hearing ability? [NB For adult participants only]

No change; Yes – changed a little; Yes – changed a lot.

Q. Have you ever had tinnitus? (i.e. ringing, buzzing or other sounds in your ears or head).

No; Yes – sometimes; Yes – often; Yes, all the time.

Q. How long does the tinnitus usually last?

(1) < one minute; (2) A few minutes; (3) Up to an hour; (4) Hours to days; (5) Always present.