

Leisure noise exposure: Participation trends, symptoms of hearing damage, and perception of risk

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Abbreviations: ADE: acceptable daily exposure; AYE: acceptable yearly exposure, L_{Aeq} : A-weighted equivalent continuous sound pressure level

Objective: Leisure activities that emit high noise levels have the potential to expose participants to excessive noise exposure, which can result in hearing damage. This study investigated young people's participation in high-noise leisure activities and the relationship between their leisure noise exposure, symptoms of hearing damage, and perception of risk.

Design: Participants completed an online survey relating to participation in selected high-noise leisure activities, symptoms of hearing damage, and beliefs about the risk posed by these activities.

Study Sample: 1000 18- to 35-year-old Australian adults completed the survey.

Results: Annual noise exposure from the five leisure activities ranged from 0 - 6.77 times the acceptable noise exposure, with nightclubs posing the greatest risk. Those who attended one noisy activity were more likely to attend others, in particular nightclubs, pubs, and live music events. Noise exposure was correlated with early warning signs of hearing damage and perceived risk of damage.

Conclusions: Active young adults who engage in noisy activities are showing early signs of hearing damage. Furthermore, they perceive the risk associated with their activities. The challenge for researchers and hearing health practitioners is to convert self-perceived risk into positive hearing health behaviours for long-term hearing health.

In a recent study we estimated that 14.1% of young Australian adults may be at risk of noise-induced hearing loss (Beach et al, in press), a figure which is comparable with estimated proportions of those at risk in samples of a similar age in the US and UK (Smith et al, 2000; Neitzel et al, 2004). The 14.1% estimate was reached by calculating the annual noise exposure of 1000 young Australian adults at five selected high-noise leisure activities popular amongst young Australians: i) nightclubs; ii) pubs, bars and registered clubs; iii) fitness classes; iv) live sporting events; v) concerts and live music. This list is not intended to be an exhaustive list of high-noise leisure activities, but a representative list that was chosen to cover a range of high-noise activities that are well patronised by young Australians. Please see Beach et al (in press) for a detailed explanation of why these particular activities were chosen. Annual noise exposure was calculated in AYE (acceptable yearly exposure) units, a method based on the Australian daily workplace noise limit of $L_{Aeq,8h} = 85$ dBA (Standards Australia, 2005). This method has been described fully in Williams et al (2010) and Beach et al (in press). Briefly, the AYE is calculated by adding together a person's total acceptable daily exposures (ADEs) from various sources across a year, (where one acceptable daily noise dose is $1.01 \text{ Pa}^2\text{h}$ or 1 ADE), and dividing this by 220, the assumed number of noise-exposed workdays per year.

As might be expected, the Beach et al study found that yearly noise exposure (in AYE) decreased for older participants, with the percentage considered to be at risk dropping from 17.8% for 18- to 24-year-olds to 7.8% for 30-to 35-year-olds. Of the five activities, the one that posed the greatest threat to hearing health was nightclub attendance, which accounted for 70% of the total leisure noise exposure experienced by the sample. In general, males and females received similar annual noise exposures from their leisure activities, except where education levels were low. In this case, males experienced more leisure noise exposure than females. Previous studies of young adults have reported comparable results, finding either no gender differences in overall leisure noise exposure

(e.g., Bohlin & Erlandsson, 2007; Jokitulppo & Bjork, 2002) or that males are more noise-exposed than females (e.g., Smith et al, 2000). Although socio-economic status has not previously been linked to noise exposure per se, lower socio-economic status has been shown to be associated with less negative attitudes towards noise (Olsen Widén & Erlandsson, 2004).

It is important to know as much as possible about the characteristics of those who are at risk of hearing damage as a result of their leisure activities. A good understanding of the leisure behaviour, participation patterns, and typical demographic characteristics of those at risk will assist in the development of effective prevention messages that are targeted and relevant to those most in need of them. Leisure noise research has repeatedly shown that the majority of young adults are *not* at risk of hearing damage from leisure noise (Smith et al, 2000; Jokitulppo & Björk, 2002; Neitzel & Seixas, 2005), and therefore broad based messages are unlikely to be as effective as more focussed prevention messages tailored for those most in need of prevention advice. Prevention messages need to engage the target audience in a way that highlights the reality of the threat posed by participating in particular leisure behaviours while also providing appropriate suggestions regarding how to best reduce their risk levels. Messages that are too broad in scope run the risk of being dismissed as irrelevant by those most in need of them.

In order to explore leisure participation patterns further and gain a more complete understanding of those most at risk, this study was designed to investigate how age, gender, and educational attainment affected participation patterns for each of the five leisure activities. We also investigated whether those who participate in one noisy activity were more likely to attend other noisy activities, and if so, which ones. A further aim of the study was to investigate whether estimated noise exposure was associated with personal perceptions of risk, and indicators of hearing damage such as tinnitus, and difficulty hearing in noise. That is, are those who receive the most leisure-related noise

showing signs of the effects of that noise, and are they aware that they may be damaging their hearing?

MATERIALS AND METHODS

Ethics approval for this study was obtained through the Australian Hearing Human Research Ethics Committee.

Participants

A total of 1000 young adults aged 18-35 years agreed to complete an online research survey regarding noise exposure and behaviour. Prior to the study, participants were advised that the survey was “about important issues facing our community” and were not provided any information about the survey’s subject matter or intended purpose. Participants were members of a large online research panel, compiled by an independent research company which assembles the panel to ensure it is in line with general population statistics provided by the Australian Bureau of Statistics. Full details can be found in Beach et al (in press) . The final sample covered a diverse range of participants drawn from both regional and metropolitan areas of all states of Australia, each represented in accordance with population statistics: NSW – 29%; VIC – 27.7%; QLD – 20.3%; WA – 11.4%, SA – 7.4%; TAS – 2.1%; ACT – 1.5%; NT - 0.6%. The gender distribution was: females 57%; males 43%, and the proportion of participants in each age group was well balanced: 18-24 years - 34%; 25-29 years - 34%; 30-35 years - 32%. The participants showed varying potential risk for noise-induced hearing loss, with estimated leisure exposures ranging from 0 to 6.77 AYE, (M=.48, SD=.83) (Beach et al, in press).

Procedure

The authors collaborated with a market research company, Inside Story, to develop an online questionnaire. The questionnaire comprised 25 questions and took approximately 15 minutes to

complete. See Beach et al (in press) for further details. The questions and response codings (where relevant) are shown in Table 1. In questions A and B, respondents were asked to “think about activities and events you participate in outside of work” and provide details of their frequency of attendance and average length of visit at each of five leisure activities. The activities chosen are attended regularly by young adults, and have been identified in the literature as high-noise and thus high-risk activities: nightclub or dance music venue; pub or registered club; fitness class set to music; sporting event; music concert or live music venue. In questions 1-5, respondents were asked about their hearing health and their self-perceived risk of hearing loss. Participants were also asked a series of questions about their noise reduction behaviour and attitudes and knowledge of noise and hearing loss. Results pertaining to these questions can be found in Gilliver et al, this volume.

***** INSERT TABLE 1 HERE *****

Data Analysis

Data were analysed using Statistica, version 10 (StatSoft Inc, 2011). In order to explore participation trends in relation to age, and education, non-parametric methods were used because the dependent variable (hours of attendance) was not normally distributed. Spearman’s correlation coefficients were calculated to determine whether participants were likely to attend more than one type of noisy leisure activity. Logistic regression was used to analyse whether AYE levels were associated with an increased self-perception of risk and the various indicators of hearing damage.

RESULTS

Participation Trends

Table 2 shows the mean noise levels and participation rates for each of the five leisure activities.

Nightclubs are the loudest of the five leisure activities and thus pose the highest risk per hour of attendance, with levels more than 2.5 times that posed by the next loudest activity, sports events. Furthermore, as shown in Table 2, nightclubs are patronised by 81% of 18- to 35-year-olds and are thus likely to be a major culprit in the accumulated leisure noise exposure levels of many young people. For the 8.3% who attend nightclubs weekly, a single visit (for the average 3.3 hours at 2ADE/hour) would result in exposure levels that exceed an entire weekly workplace allowance.

*** INSERT TABLE 2 HERE ***

Gender. There were significant gender differences in frequency of attendance at sports events and fitness classes. More males than females attended sports events (79.7% vs 71.6%, $z = 2.93$, $p < .01$) and more females than males attended fitness classes (58.5% vs 43.6%, $z = 4.67$, $p < .001$). For attendance at pubs, nightclubs and concerts, there were no significant gender differences. See Figure 1.

*** INSERT NEW FIGURE 1 HERE ***

Kruskal-Wallis tests were performed for each leisure activity to see whether age and/or education affected yearly attendance rates. The independent variables were: Age group (18-24, 25-29, 30-35) and Education level (some primary or secondary education; completed secondary education; completed a trade or technical qualification; or completed a university degree). The dependent variable was total attendance hours per year.

Age. The results showed a significant effect of age on attendance at nightclubs, $H(2) = 54.41$, $p < .001$ and pubs, $H(2) = 15.97$, $p < .001$. Figure 2 shows the attendance patterns for each age group for each of the five leisure activities: For nightclubs, attendance declined with age, and for pubs, attendance

peaked for 25- to 29-year-olds. For the other three leisure activities, the annual attendance hours were lower and remained steady across the three age groups.

*** INSERT NEW FIGURE 2 HERE ***

Education. There were no significant effects of education. However, the result for concerts, $H(3)=7.39$, $p=.06$, approached significance, suggesting that those with a post-school education spent more time at live music concerts and venues than those with less educational attainment. See Figure 3.

*** INSERT NEW FIGURE 3 HERE ***

Patterns of Participation. Spearman's correlations were performed using participants' annual attendance rates (visits per year) for each of the five activities to determine whether participation in one activity was associated with participation in other noisy activities. Although correlation strength was only weak to moderate, all activities were significantly positively correlated, all $p<.01$, suggesting that those who participated in one noisy activity were likely to participate in others. The strongest correlations indicated that those who report high participation in nightclubs were also likely to report high participation in pubs ($r_s=.58$) and live music events ($r_s=.61$).

*** INSERT TABLE 3 HERE ***

Noise exposure and Risk. Ordinal logistic regression, with AYE as the predictor variable, was used to investigate whether an increase in AYE predicted an increase in the self-perceived risk of hearing loss (question 5). The results showed a significant relationship, $OR=1.64$, 95%CI, 1.42-1.90, $p<.001$, indicating that greater leisure noise exposure was associated with greater perceived risk of hearing loss. See top panel of Figure 4.

*** INSERT FIGURE 4 HERE ***

Noise exposure and indicators of hearing damage. Again using AYE as the predictor variable, ordinal logistic regression was used to investigate whether an increased AYE predicted the degree of self-rated hearing loss (question 1) and the number of indicators of hearing damage a person experienced. A total score out of three was calculated based on positive responses to questions 2-4. That is: difficulty hearing in noise (yes=1, no=0); family concern about your hearing (yes=1, no=0); and occurrence of tinnitus (sometimes, often or always = 1, never or occasionally = 0). The results showed that an increase in AYE was associated with a significant increase in number of indicators present, $OR=1.30$, 95% CI, 1.14-1.50, $p<.001$, (see middle panel of Figure 4) but not self-rated hearing loss, $OR=1.04$, 95% CI, .91-1.19, $p=.56$.

To further examine which of the three indicators of hearing damage (difficulty hearing in noise, family concern, and tinnitus) were predicted by an increase in AYE, three additional logistic regressions were performed. Results showed that an increase in AYE was associated with: increased family concern, $OR = 1.26$, 95% CI, 1.07-1.47, $p<.01$ and more frequent tinnitus, $OR = 1.32$, 95% CI, 1.15-1.52, $p<.001$, but not difficulty in hearing in noise, $OR=1.11$, 95%CI, .95-1.29, $p=.19$. The relationship between AYE and occurrence of tinnitus is shown in the bottom panel of Figure 4.

DISCUSSION

Of the five leisure activities studied here, nightclubs pose, by far, the greatest risk to the hearing of participants. The typically high noise levels and prolonged attendance at nightclubs combine to make nightclubs a high-risk activity, and one that has been highlighted by other researchers (Smith et al, 2000; Jokitulppo & Bjork, 2002; Vogel et al, 2010). A typical 3.3-hour weekly visit is equivalent to 6.55 ADEs (which is more than one week's acceptable workplace exposure, 5 ADEs) and thus

anyone who attends nightclubs at least this frequently without hearing protection is putting their hearing at risk. Since the data suggest that nightclub attendees are also attending other noisy activities, such as live music events and pubs, the risk for these people is potentially greater than the nightclub figures alone suggest. Added to this is the possibility that at least some nightclub attendees also receive workplace noise exposure, or exposure from other high-noise activities not studied here, such as firearm use, riding a motorcycle, or listening to music through speakers or headphones, which, were they added here, would result in an even greater risk of hearing damage.

The analyses of participation trends showed that nightclub attendance was most common amongst 18- to 24-year-olds, while pub attendance peaked at 25-29 years, and attendance at other events varied little between the ages of 18 and 35. Females were more likely than males to attend fitness classes, and males were more likely to spend more time at live sports, a result similar to that reported for 15- to 20-year-olds in Sweden (Bohlin & Erlandsson, 2007). Apart from this, there was little evidence of a gender difference in time spent at leisure activities, a result that was to be expected since the overall noise exposure between males and females did not differ (Beach et al, in press). A small effect of education was seen in concert attendance. Those holding a trade or university qualification spent more time at concerts, a finding perhaps related to disposable income: that is, those with higher educational attainment are likely to have greater disposal income to spend on expensive concert tickets.

These participation trends provide valuable information which can be used to develop strategies for targeting those most at risk from leisure noise exposure. Since the most prolific nightclub attendees are between 18 and 24 and equally likely to be male or female, it would seem useful to direct hearing health messages to high school students and first-year university students, many of whom are about to embark on several years of regular nightclubbing.

Although nightclubs are the noisiest venues and pose a significant risk to hearing, they are not necessarily the best environment in which to impart hearing health messages, primarily because they are so noisy. Either creative solutions need to be found, perhaps posting messages in restrooms which are relatively quiet and well-lit, or else venues such as pubs and music concerts, which nightclub attendees also attend, could be used for presenting hearing health messages. For example, simple messages on drinks coasters and concert tickets could be an effective way to reach the target audience. Messages conveyed at pubs may be particularly effective in terms of generating discussion amongst young people because pubs are quieter environments in which people are inclined to talk and socialise and thus may be more likely to take time to read such messages. More detailed hearing health messages could be placed on music websites and in entertainment publications that target young adults who go to pubs, concerts, and nightclubs.

Importantly, the results of this study show that greater leisure noise exposure predicted an increase in self-perceived risk of hearing loss. Furthermore, those with greater leisure noise exposure experienced more indicators of hearing damage, in particular increased occurrence of tinnitus and reported family concern. These findings support previous studies which have shown a relationship between leisure noise exposure and symptoms of hearing damage (e.g., Jokitalppo & Björk, 2002; Holgers & Pettersson, 2005). In contrast, leisure noise exposure did not predict self-rated hearing loss or difficulty hearing in noise, which suggests that subjective perceptions of hearing loss, per se, may not be reliable amongst younger adults, a conclusion also drawn by Widén et al (2009). This is despite numerous reports that such perceptions are reliable amongst older adults with age-related hearing loss (e.g., Nondahl et al, 1998; Sindhusake et al, 2001). Alternatively, the lack of a relationship between self-rated hearing loss and leisure noise exposure may simply be because any noise-related damage that may exist in this sample has not yet manifested as a noticeable hearing loss.

The strong association between leisure noise exposure and tinnitus is well known (Chung et al, 2005; Goggin et al, 2008), and the results of this study provide further evidence of the causal effects of loud noise on the experience of tinnitus. Tinnitus is an important tool for hearing health campaigners because it is a salient symptom that many young people have experienced. Unlike eventual hearing loss, which is a distant possibility, and one that young adults are unlikely to find relevant, tinnitus has the potential to be a key element of prevention campaigns which seek to explain the undesirable effects of loud noise. Campaigners can present tinnitus as an important warning sign that should not be ignored. Previous research (Beach et al, 2012; Widén et al, 2009) suggests that tinnitus and other symptoms such as noise sensitivity can encourage some young adults to take up protective behaviours, and we believe that a particular focus on tinnitus and other symptoms is likely to be effective in encouraging young adults to take action to avoid or reduce their noise exposure.

The limitations of this study are common to all research surveys that rely on the accuracy of participants' recall of past events. In this survey participants were required to remember past leisure events and generalise about their usual pattern of attendance using a set of pre-determined responses. These closed-set responses, which were used to measure frequency and duration of attendance, ensured that the survey was simple and easy to complete. However, use of these response sets may have reduced overall response variability and obscured actual variation in the noise exposure of the group studied. Results from future studies which prospectively measure noise exposure using dosimetry could be used to verify the participation trends and exposure results reported here, and perhaps reveal any differences that might exist between perceived and actual noise exposure.

Conclusions

The results of this study show that young adults who spend many hours per year at nightclubs, concerts and pubs are being exposed to excessive leisure noise and experiencing early warning signs of hearing damage. In many cases, these young people have recognised the risk associated with their noise exposure and some have started to action to reduce that risk (see Gilliver et al, this volume). The challenge for researchers and hearing health practitioners is to target these young adults at risk and present them with hearing health messages that are relevant and accessible to them. In doing so, we have the potential to take advantage of young adults' risk awareness and transform it into positive hearing health behaviours which will reduce hearing damage and ensure long-term hearing health.

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TABLE 1: Survey questions about participants' participation in leisure activities, hearing health and perceived risk.

* 'Unsure' and 'Don't Know' responses were excluded from the analyses.

QA. How often are you involved in these activities? (Activities a-e were rotated)

a. Attend a live sporting event

b. Visit a pub or registered club eg RSL club

c. Attend a fitness class set to music eg aerobics, spin

d. Go to a concert or live music venue

e. Go to a night club or dance-music venue

More than once a week (102); Once a week (52); Once every 2 to 3 weeks (22); Once a month

(12); Once every 2 to 3 months (5); Once every 4 to 6 months (2.5); Once or twice a year (1.5);

Less than once a year (0.5); Never (0)

QB. Thinking of your average visit, how long would you be at (each of the events a-e above)

Less than an hour (0.5); Between 1-3 hours (2); Between 3-5 hours (4); More than 5 hours (6)

Q1. How would you rate your hearing?

Almost perfect/perfect (1); very good (2); good (3); neither good nor poor (4); Sometimes poor

(5); Most times poor (6); Very poor (I can hardly hear) (7)

Q2. Do you have trouble hearing when there is background noise?

Yes (1); No (0)

Q3. Do any members of your family or close friends ever say they think you have a hearing

loss?

Yes (1); No (0)

Q4. Do you ever experience ringing or buzzing in your ears (ie tinnitus)?

[Never (1); Occasionally (2)] = 0; [Sometimes (3), Often (4); Always (5)] = 1; Unsure*

Q5. Thinking of your current lifestyle and leisure activities, how would you describe the risk of it leading to some degree of permanent hearing loss?

No risk of hearing loss (1); A very small risk of hearing loss (2); A small risk of hearing loss (3); A medium risk of hearing loss (4); A large risk of hearing loss (5); A very large risk of hearing loss

(5); Don't know*

TABLE 2: Noise Levels and Participation Rates for the Five Leisure Activities.

* ADE = $[4 \times T \times 10^{(0.1 \times (L_{Aeq} - 100))}] / 1.01$, where T= time in hours.

Activity	Noise Levels		Participation Rates				Noise x Participation	
	L _{Aeq} M (SD)	ADE* /hr	Participation (at least yearly)	Participation (weekly)	Mean Frequency (visits/year)	Mean Duration (hrs/visit)	Average ADE/visit	Average ADE/year
Pub or registered club	84 (6.8)	.1	88%	14.2%	15	2.7	.27	4.05
Fitness class	86 (5.5)	.16	51%	14%	13	1.4	.22	2.86
Concert or live music venue	92 (7.3)	.63	76%	3.4%	5	3.0	1.88	9.4
Sporting event	93 (4.7)	0.8	75%	4.9%	6	2.5	1.98	11.88
Nightclub	97 (4.9)	2	81%	8.3%	10	3.3	6.55	65.5

TABLE 3: Matrix of correlation coefficients for attendance at the five leisure events. All coefficients significant at $p < .01$. For each correlation, the percentage of people who attended both events is reported in brackets (%).

	Pubs	Fitness Classes	Concerts	Nightclubs
	r (%)	r (%)	r (%)	r (%)
Sport	.40 (70.6)	.35 (46.2)	.46 (68.9)	.42 (66.8)
Pubs		.23 (49.3)	.47 (78.4)	.58 (77.3)
Fitness Classes			.34 (48)	.36 (47.9)
Concerts				.61 (73.5)

FIGURE LEGENDS

Figure 1: Percentage of males and females who participate in each of the five leisure activities. Errors bars = 95% CI.

Figure 2: Attendance hours per year at the five leisure activities for each age group. Errors bars = 95% CI for the mean.

Figure 3: Attendance hours per year at live music concerts for each educational attainment group. Errors bars = 95% CI for the mean.

Figure 4: AYE as a function of risk, tinnitus, and number of indicators of hearing damage. Errors bars = 95% CI for the mean.

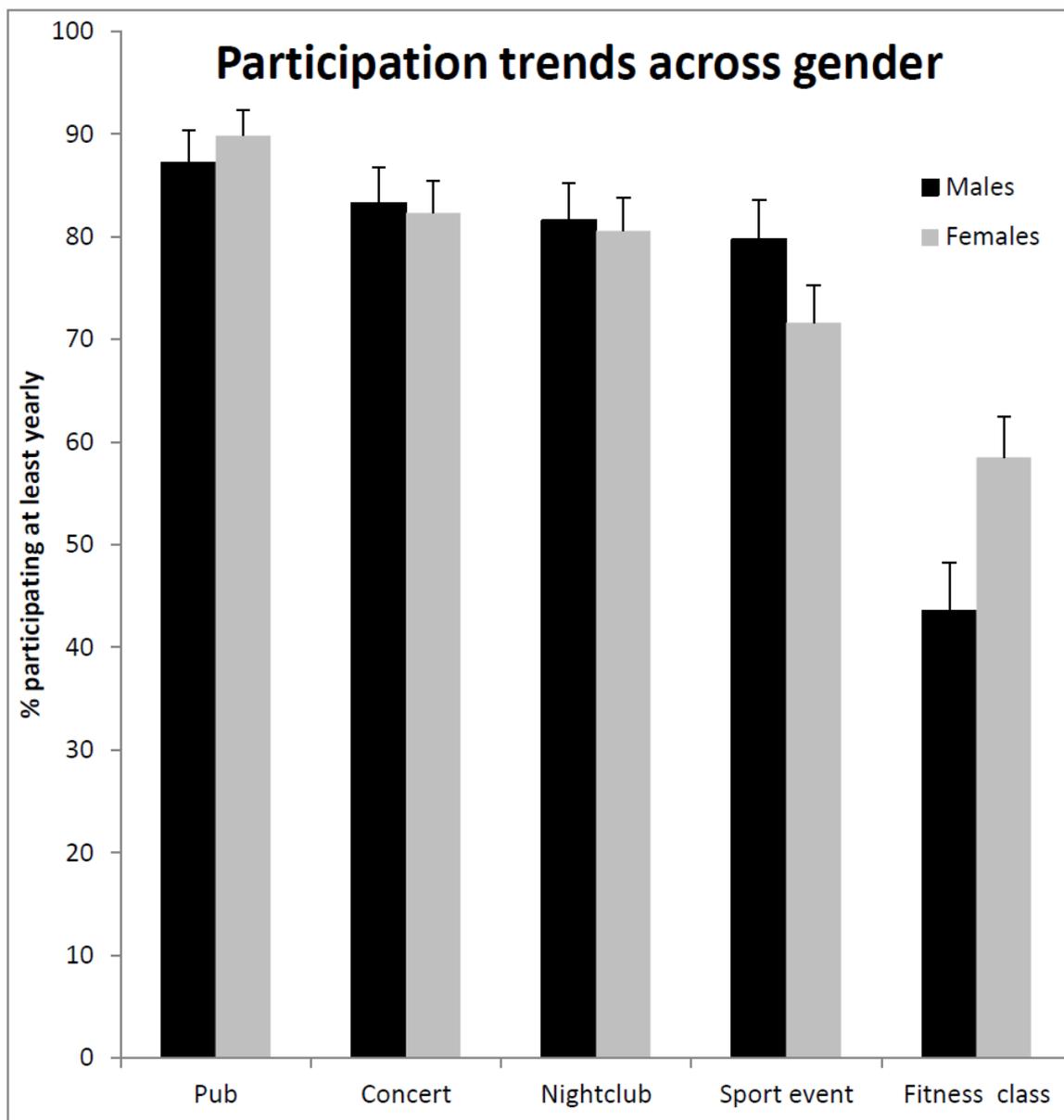


FIG 1

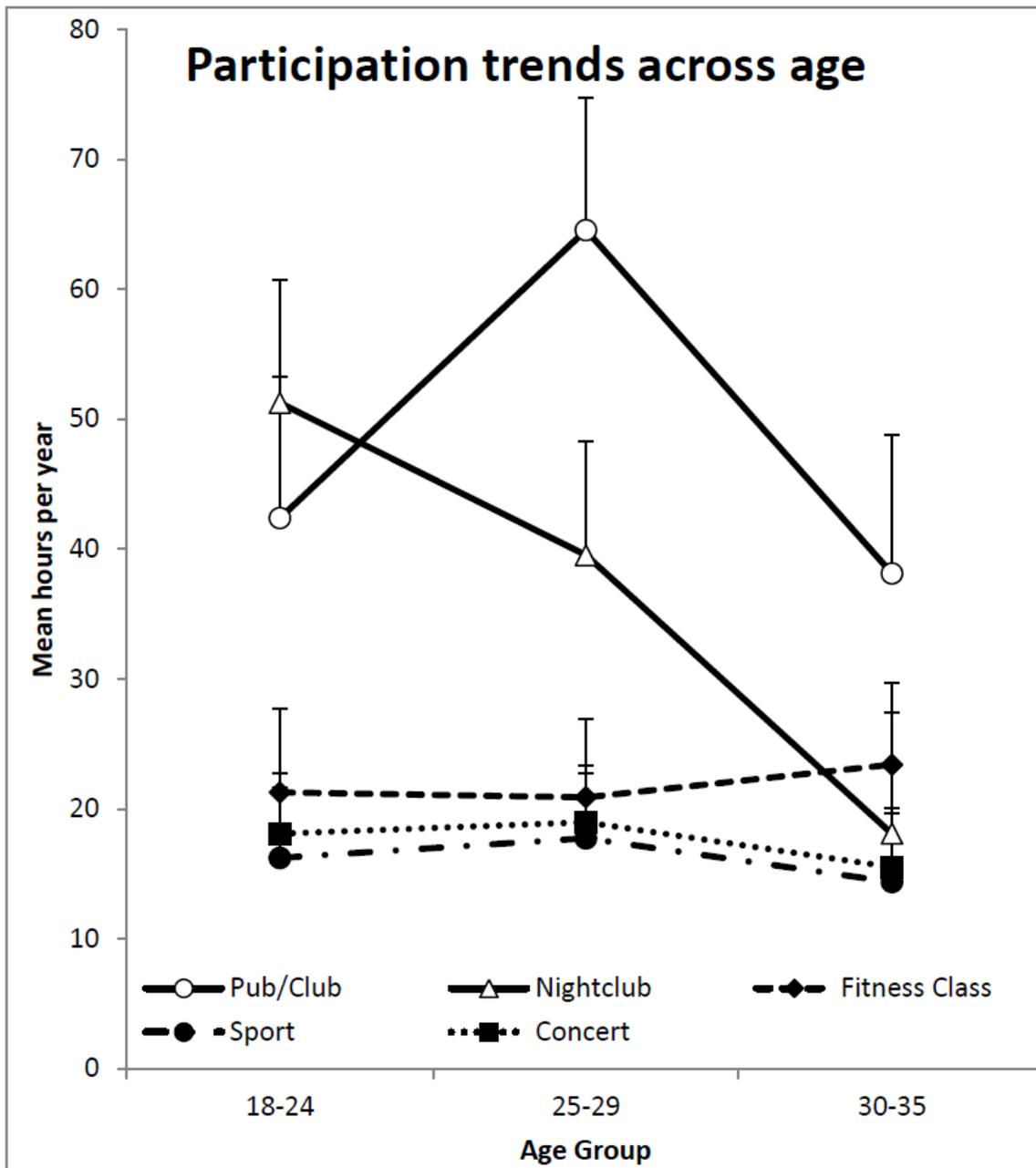


FIG 2

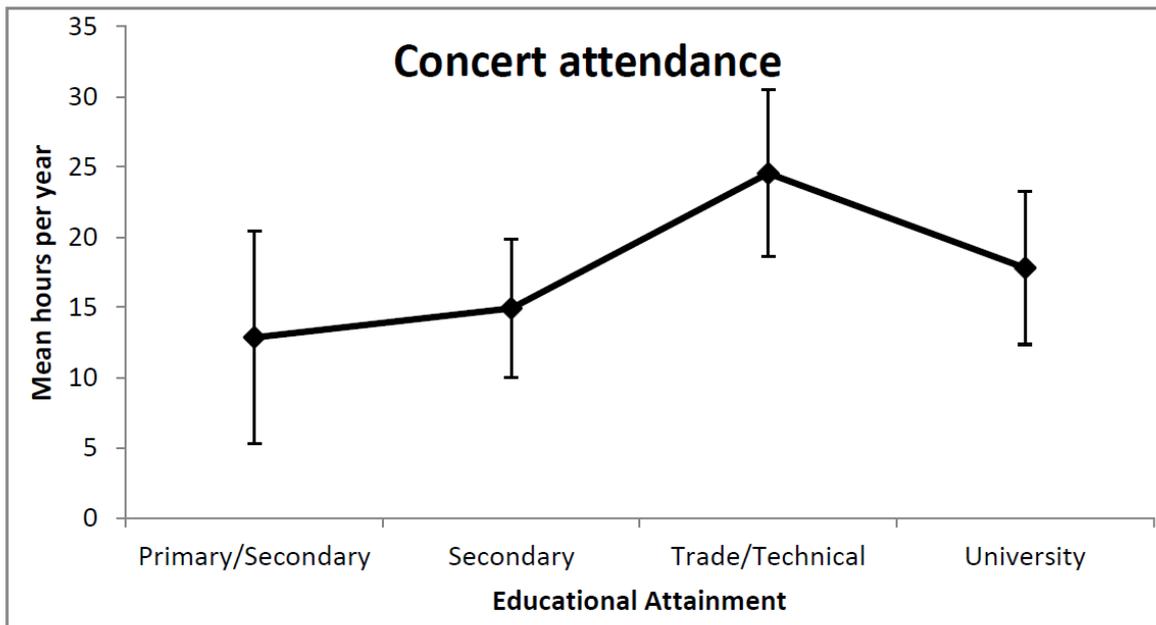


FIG 3

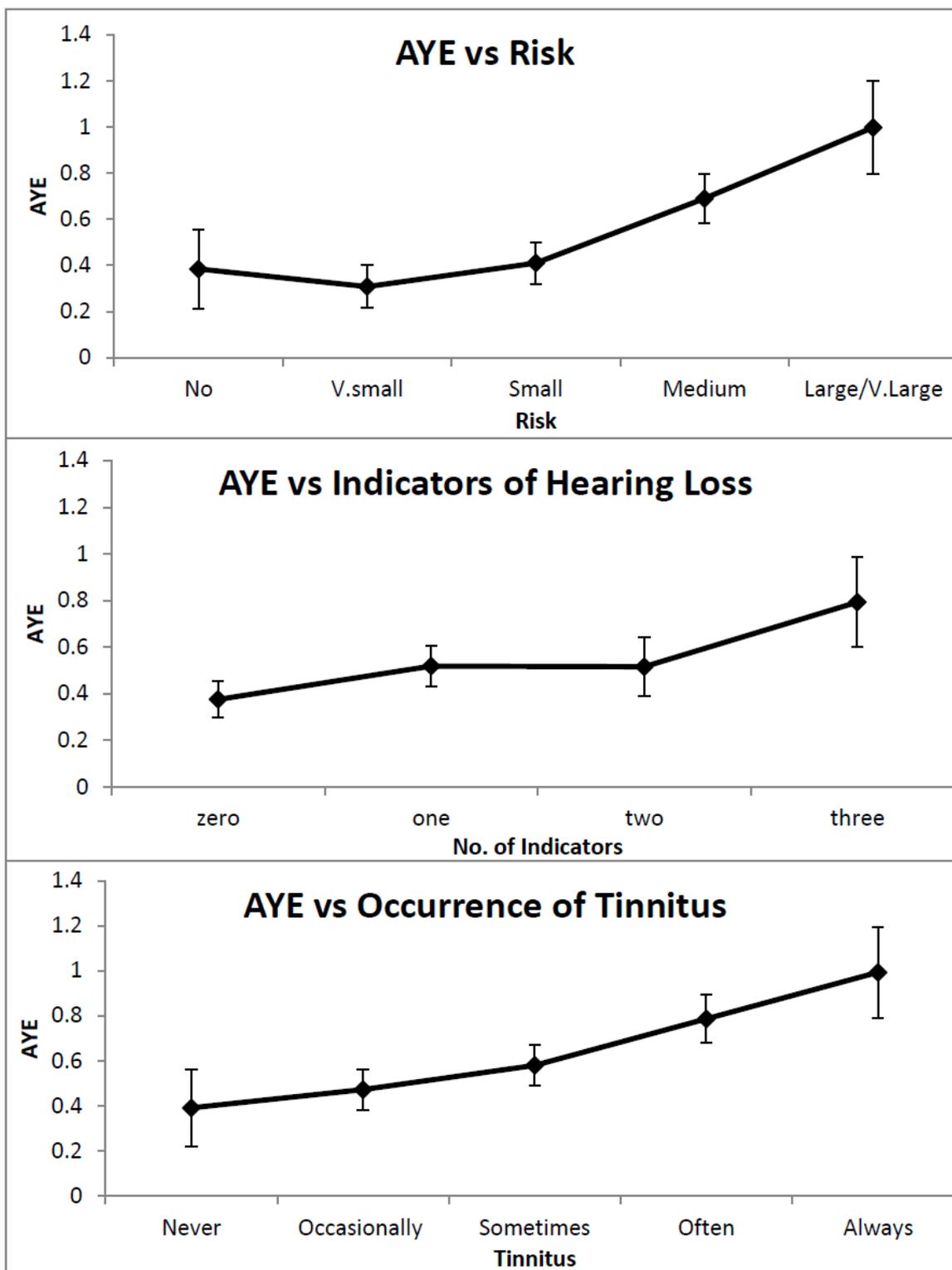


FIG 4