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ORIGINAL ARTICLE



# "Can physical activity reduce the risk of having tinnitus?"

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**ABSTRACT**

**Objective:** Tinnitus, the perception of sound without an external source, affects many adults, impacting quality of life. While factors like hearing loss and psychological distress are linked to tinnitus, the relationship with physical activity remains unclear. This study aimed to explore the association between physical activity, sedentary behaviour, and the presence of tinnitus.

**Design:** This study is a cross-sectional study. The participants completed the long form of the International Physical Activity Questionnaire. Adjusted logistic regression models were used to investigate associations between (components of) physical activity and the presence of tinnitus, and odds ratios (ORs) were calculated.

**Study Sample:** This study involved 3004 participants (2751 tinnitus patients, 253 healthy controls).

**Results:** Engaging in moderate or vigorous-intensity physical activity during leisure time for more than 2.5 hours per week was associated with a reduced risk of having tinnitus (OR = 0.515, $p < 0.001$). Conversely, individuals who reported sitting for more than 7 hours per day had a significantly higher risk of having tinnitus (OR = 2.366, $p < 0.001$).

**Conclusions:** The study suggests a potential protective effect of leisure-time physical activity against tinnitus and highlights the importance of reducing sedentary behaviour. Further research is needed to confirm these findings and to understand underlying mechanisms.

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Tinnitus; prevention; physical activity; odds ratio; sedentary behaviour

## Introduction

Tinnitus, defined as the perception of sound without the presence of an external source for the sound, affects about 15% of the adult population (Jarach et al. 2022). It is commonly associated with hearing loss or noise-induced trauma, with cochlear abnormalities serving as the initial source of the condition, while neural changes in the central nervous system perpetuate (Baguley, McFerran, and Hall et al. 2013). Tinnitus is also influenced by a range of biopsychological factors, including anxiety (Bhatt, Lin, and Bhattacharyya et al. 2016), depression (Bhatt, Lin, and Bhattacharyya 2016), stress (Mazurek, Szczepek, and Hebert 2015), and neck or temporomandibular dysfunctions (Buergers et al. 2014; Michiels et al. 2015; Van der Wal et al. 2020, 2022).

Emerging research suggests that physical activity may have a beneficial effect on tinnitus. Physical activity improves cardiovascular function and health, which may increase blood flow to the inner ear, potentially protecting against tinnitus (Jafari, Kolb, and Mohajerani 2019; Nystoriak and Bhatnagar 2018). Apart from increases in blood flow to the inner ear, physical activity also improves the overall blood flow to the brain (Barnes 2015). This elevation of perfusion levels in the brain might play an important role in tinnitus, as Zimmerman et al. (2021) found significant differences in both global gray and white matter perfusion between tinnitus patients and control subjects. Control subjects in this study showed a higher perfusion in the gray matter compared to tinnitus patients, where the white matter perfusion was higher in tinnitus patients (Zimmerman et al. 2021). Furthermore, decreased tinnitus symptoms have been linked to increased cognitive control, as evidenced by increased frontal cortex activity in physically active individuals (Carpenter-Thompson, McAuley, and Husain 2015). In addition, exercise can help to decrease the risk of hypertension (Hegde and Solomon 2015) and obesity (Silveira et al. 2022), whereas, sedentary behaviour is associated with an increased risk of hypertension (Gamage and Seneviratne 2021) and obesity (Silveira et al. 2022), all of which are risk factors for tinnitus (Figueiredo, Azevedo, and Penido 2016).

Despite these potential benefits, the relationship between physical activity and tinnitus is not fully understood, and studies have yielded contradictory results. Previous studies have indicated a potential association between tinnitus prevalence and physical activity levels, suggesting that individuals who engage in regular physical activity may be less likely to experience tinnitus. One study showed that older adults with hypertension were 21% less likely to have tinnitus for every 60-minute increase in low-level physical activity (Loprinzi et al. 2013). Likewise, adolescents were 4% less likely to have tinnitus for more than three months for every minute of moderate to vigorous physical activity (Loprinzi et al. 2013). Furthermore, the study of Chen et al. (2023) found that only 12.8% of individuals who engaged in regular physical activity reported tinnitus, compared to 18.5% among those who did not ($p = 0.005$). Furthermore, subgroup analyses showed that those engaging in 150 to 4800 minutes of physical activity per week had significantly lower odds of reporting tinnitus (OR = 0.72, 0.56, and 0.62, respectively), after adjusting for confounders (Chen et al. 2023). These findings are,

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however, contradicted by the study of Nondahl, et al. (Nondahl et al. 2011) which found no significant association between self-reported exercise and the presence of tinnitus (Nondahl et al. 2011).

In addition, Carpenter-Thompson, McAuley, and Husain (2015) found an association between decreased physical activity and increased tinnitus severity, suggesting that regular exercise might help to decrease tinnitus severity (Carpenter-Thompson, McAuley, and Husain 2015). These results, however, were not confirmed by a recent study of Chen et al. (2023). Due to the contradictions found in currently available studies, the role of regular physical activity in reducing the risk of having tinnitus remains unclear. Differences in study design, population age, and measurement methods may account for these discrepancies. For instance, variations in how physical activity is quantified—self-reported exercise versus validated questionnaires—can lead to different outcomes. Additionally, the intensity and type of physical activity, as well as underlying health conditions, might influence the association with tinnitus. Resolving these contradictions is crucial for the field, as it can guide more effective interventions and recommendations for individuals at risk of or suffering from tinnitus. Therefore, this study aimed to investigate the relationship between physical activity type and level, sedentary behaviour, and the presence of tinnitus.

## Methods

### Survey

In June 2022, an online survey (Qualtrics) was launched in a convenience sample of adult participants with and without tinnitus. Only patients with subacute or chronic tinnitus were included in this study (>3 months tinnitus duration). Patients who had tinnitus duration less than three months were excluded from this study. This survey included the International Physical Activity Questionnaire (IPAQ) to assess adherence to national and international physical activity recommendations (Fan, Lyu, and He 2005; van Poppel and Paw 2004; Vandelanotte et al. 2005; World Health Organization 2020). The IPAQ evaluates physical activity during the last week across multiple domains, including leisure time, domestic and gardening activities, and work-related and transport-related activities. The IPAQ defines moderate activity as activities performed for at least 10 minutes that cause sweating and increased respiration and heart rate. Vigorous activities are defined as those that produce greater respiration, heart rate, and sweating increases. Apart from the IPAQ, participants were asked for their age, gender, body weight, height, and if they have tinnitus. The final questionnaire consisted of 48 questions (see Appendix 1).

The survey was advertised via the national news, social media, and several tinnitus forums. It was launched as an open survey to everyone who received the link. IP address check was used to identify potential duplicates from the same user. All participants gave their digital informed consent to use their anonymised data. No personal information was collected during the process. Ethical approval was obtained from the local ethics committee (ref. B1152022000005) and the study was performed in accordance with the latest version of the Declaration of Helsinki.

### Data analysis and statistical analysis

Before data analysis, the International Physical Activity Questionnaire (IPAQ) data was used to calculate the duration of various types of physical activity. Specifically, the number of hours engaged in vigorous, moderate, and walking activities during both work and leisure time were calculated, along with cycling and walking time during transportation and vigorous and moderate activity time during yard or gardening work and inside-home tasks. The amount of time spent sitting during transportation, on weekdays, and during weekends was also determined. Afterwards, categorical scores were added, using three categories based on physical activity level. Individuals with low physical activity scores were classified as Category 1, while those with moderate or high physical activity levels were classified as Category 2 or 3, respectively. Individuals who do not meet the criteria for categories 2 or 3 are considered to have low or inactive lifestyles. To be classified as category 2, participants should meet at least one of the following criteria: engaging in vigorous activity for three or more days, with each session lasting a minimum of 20 minutes per day, or participating in moderate-intensity activity such as walking for a duration of at least 30 minutes per day on five or more days, or pursuing a combination of walking, moderate-intensity, or vigorous-intensity activities for a total of at least 600 MET-min/week (Metabolic Equivalent of Task minutes per week) on five or more days. To be classified as category 3, participants need to meet at least one of the following criteria: engaging in vigorous-intensity activity on a minimum of three days and accumulating at least 1500 MET-minutes/week, or participating in a combination of walking, moderate-intensity, or vigorous-intensity activities for a total of at least 3000 MET-minutes/week over seven or more days. Scores were calculated by converting the duration of various activities into METs and subsequently determining total MET-minutes per week. Each activity was assigned a specific MET value, reflecting its intensity. Walking was assigned a MET value of 3.3, moderate-intensity activities were assigned a value of 4.0 METs, and vigorous-intensity activities were assigned a value of 8.0 METs. Participants reported the average daily time spent on these activities. MET-minutes per week for each activity were computed by multiplying the MET value by the daily duration of the activity and then summing these values over a week. The total physical activity score was obtained by summing the MET-minutes per week across all activities (Craig et al. 2003).

Insufficient physical activity was defined according to the World Health Organisation (WHO) guidelines as individuals reporting less than 150 minutes of combined moderate and vigorous physical activity per week (World Health Organization 2020). Sitting time during transportation, weekdays, and weekends was also measured, and total sitting time was calculated. Participants were classified as sitting more or less than 7 hours per day based on meta-analytic evidence of increased risk of sitting-related diseases after 7 hours of sitting per day (Chau et al. 2013).

Descriptive statistics were utilised to present the main characteristics of the study participants. Continuous variables were summarised using means and standard errors. To evaluate the potential influence of tinnitus status on participant characteristics, the distribution of various factors was examined using the chi-square test for categorical variables, while t-tests were used for continuous variables. The statistical significance level was set at 0.05. Logistic regression models were applied to investigate the relationship between physical activity variables and the presence of tinnitus, and odds ratios (ORs) were calculated. The logistic regression models were applied in three steps: first unadjusted, second adjusted for age and sex alone, and third adjusted for age, sex, hearing loss, noise trauma, noise exposure, and psychological symptoms (stress, anxiety and depression). The results

**Table 1.** Logistic regression results for the IPAQ questionnaire.

| | *Unadjusted* | | | *Adjusted for age and sex* | | | *Adjusted for age, sex, hearing loss, noise trauma, anxiety, depression and stress* | | |
|---|---|---|---|---|---|---|---|---|---|
| Variables | OR | 2.5% | 97.5% | OR | 2.5% | 97.5% | OR | 2.5% | 97.5% |
| Work vigorous | 1.002 | 0.974 | 1.036 | 1.004 | 0.976 | 1.04 | 0.998 | 0.97 | 1.032 |
| Work moderate | 0.986 | 0.965 | 1.01 | 0.995 | 0.973 | 1.02 | 0.996 | 0.973 | 1.021 |
| Work walk | 1.018 | 0.993 | 1.05 | 1.026 | 1 | 1.059 | 1.02 | 0.994 | 1.052 |
| Work | 1.001 | 0.99 | 1.013 | 1.005 | 0.994 | 1.018 | 1.003 | 0.992 | 1.015 |
| Transportation cycling | 1.022 | 0.996 | 1.054 | 1.007 | 0.982 | 1.038 | 1.01 | 0.985 | 1.043 |
| Transportation walking | 1.012 | 0.989 | 1.041 | 0.996 | 0.975 | 1.022 | 0.992 | 0.969 | 1.018 |
| Yard vigorous | 1.009 | 0.977 | 1.048 | 0.983 | 0.954 | 1.02 | 0.978 | 0.947 | 1.015 |
| Yard moderate | 1.033** | 1.003 | 1.067 | 1.003 | 0.976 | 1.034 | 1.001 | 0.974 | 1.033 |
| Home indoor work moderate | 0.996 | 0.98 | 1.015 | 0.991 | 0.974 | 1.011 | 0.991 | 0.973 | 1.011 |
| Yard and Home | 1.005 | 0.994 | 1.018 | 0.995 | 0.984 | 1.008 | 0.994 | 0.982 | 1.007 |
| Leisure vigorous | 0.911*** | 0.882 | 0.943 | 0.907*** | 0.875 | 0.941 | 0.923*** | 0.885 | 0.956 |
| Leisure moderate | 0.969 | 0.936 | 1.008 | 0.932*** | 0.9 | 0.97 | 0.941** | 0.907 | 0.981 |
| Leisure walk | 1.009 | 0.985 | 1.039 | 0.992 | 0.969 | 1.02 | 0.985 | 0.961 | 1.016 |
| Leisure | 0.982*** | 0.969 | 0.997 | 0.969*** | 0.955 | 0.985 | 0.968*** | 0.952 | 0.984 |
| Total vigorous | 0.969*** | 0.95 | 0.99 | 0.971** | 0.951 | 0.993 | 0.972* | 0.951 | 0.994 |
| Total moderate | 1.002 | 0.994 | 1.011 | 0.995 | 0.986 | 1.003 | 0.995 | 0.986 | 1.004 |
| Total walk | 1.01 | 0.997 | 1.025 | 1.004 | 0.992 | 1.018 | 1 | 0.987 | 1.015 |
| Total | 1.001 | 0.995 | 1.007 | 0.996 | 0.991 | 1.002 | 0.995 | 0.989 | 1.002 |
| IPAQ category | 0.904 | 0.719 | 1.125 | 0.757 | 0.592 | 0.957 | 0.77* | 0.597 | 0.981 |
| PA >150 minutes/week (Yes) | 0.537*** | 0.408 | 0.702 | 0.48*** | 0.362 | 0.633 | 0.515*** | 0.384 | 0.687 |

*Significant at $p < 0.05$ level, **Significant at $p < 0.01$ level, ***Significant at $p < 0.001$ level, OR = Odds ratio, IPAQ = international physical activity questionnaire, PA = physical activity, every variable was measured in hours/week except IPAQ category and PA > 150 minutes/week.

**Table 2.** Logistic regression results for sitting time.

| | *Unadjusted* | | | *Adjusted for age and sex* | | | *Adjusted for age, sex, hearing loss, noise trauma, anxiety, depression and stress* | | |
|---|---|---|---|---|---|---|---|---|---|
| Variables | OR | 2.5% | 97.5% | OR | 2.5% | 97.5% | OR | 2.5% | 97.5% |
| Sitting time during transportation (hours/week) | 1.004 | 0.995 | 1.015 | 1.005 | 0.997 | 1.017 | 1.001 | 0.992 | 1.013 |
| Total sitting time(hours/week) | 0.999 | 0.995 | 1.004 | 1.002 | 0.997 | 1.007 | 1.002 | 0.997 | 1.008 |
| Sit > 7 hours/day (Yes) | 1.825*** | 1.373 | 2.452 | 2.283*** | 1.699 | 3.104 | 2.366*** | 1.743 | 3.248 |

*Significant at $p < 0.05$ level, **Significant at $p < 0.01$ level, ***Significant at $p < 0.001$ level, OR = Odds Ratio.

**Table 3.** Demographic characteristics.

| | All | | Tinnitus | | Controls | | |
|---|---|---|---|---|---|---|---|
| | n | Percentage | n | Percentage | n | Percentage | p |
| Female | 1400 | 46.6% | 1225 | 44.53% | 175 | 69.17% | <0.001 |
| Male | 1604 | 53.4% | 1526 | 55.47% | 78 | 30.83% | |
| Total | 3004 | 100% | 2751 | 100% | 253 | 100% | |
| | Mean (minimum-maximum) | SD | Mean (minimum-maximum)- | SD | Mean (minimum-maximum) | SD | p |
| Age (years) | 51.4 (18-91) | 15 | 52.3 (18-91) | 14.6 | 42.3 (18-88) | 16.3 | <0.001 |
| Height (cm) | 173.4 (142-205) | 11.1 | 173.5 (142-204) | 11.3 | 171.2 (149-205) | 9.1 | <0.001 |
| Weight (Kg) | 77.4 (40-173) | 15.9 | 78 (40-173) | 15.8 | 71 (45-129) | 15.5 | <0.001 |
| BMI (kg/m$^2$) | 25.6 (14.5-53.8) | 4.4 | 25.7 (14.5-53.8) | 4.4 | 24.1 (17.5-42.1) | 4.3 | <0.001 |

Kg = kilograms, cm = centimeters, m = meters, SD = Standard deviation.

presented below are the results from the third step alone. Detailed results from all the steps can be found in Tables 1 and 2. These adjustments were made to account for potential confounding factors and improve the regression analysis' accuracy. All statistical analyses were performed using the "stats" package in R (Core Team 2022).

## Results

### Demographics

The study sample consisted of 3004 individuals, of which 53.4% were male and 46.6% were female. Among the individuals with tinnitus ($n = 2751$), there were slightly more males, whereas, in the healthy control group (no presence of tinnitus; $n = 253$), there were more females ($p < 0.001$). The mean age of participants was 51.4 ± 15.0 years. On average, individuals with tinnitus were older, slightly taller, and had a higher body weight than those without tinnitus ($p < 0.001$). Also, the mean BMI of individuals with tinnitus was significantly higher than the BMI of those without tinnitus ($p < 0.001$). Table 3 presents the demographic characteristics of the participants with and without tinnitus. Table 4 presents the tinnitus characteristics for the tinnitus patients.

### Tinnitus and physical activity

After adjustments for potential confounders (age, sex, hearing loss, noise trauma, and psychological symptoms), our analysis

Table 4. Tinnitus characteristics.

| Tinnitus | n | Percentage |
|---|---|---|
| Female | 1225 | 44.53% |
| Male | 1526 | 55.47% |
| Total | 2751 | 100% |
| **Tinnitus Duration** | | |
| 3-6 months | 120 | 4.36% |
| 6-12 months | 114 | 4.14% |
| 1-5 years | 800 | 29.08% |
| 5-10 years | 582 | 21.16% |
| 10-20 years | 650 | 23.63% |
| More than 20 years | 485 | 17.63% |
| Total | 2751 | 100.00% |
| **Tinnitus severity** | | |
| Barely audible | 47 | 1.71% |
| Mild | 577 | 20.97% |
| Moderate | 1207 | 43.87% |
| Serious | 831 | 30.21% |
| Extreme | 89 | 3.24% |
| Total | 2751 | 100% |
| **Tinnitus Loudness** | | |
| Very soft | 110 | 4.00% |
| Soft | 391 | 14.21% |
| Moderate | 1337 | 48.60% |
| Loud | 801 | 29.12% |
| Very loud | 112 | 4.07% |
| Total | 2751 | 100.00% |

showed that individuals who perform more physical activity during leisure time are significantly less likely to have tinnitus ($p = 0.01$), especially if the intensity is moderate ($p = 0.002$) or vigorous ($p < 0.001$). Additionally, participants in the higher physical activity categories (Category 2 or 3) were significantly less likely to have tinnitus ($p = 0.039$). Likewise, individuals who adhere to the WHO recommendations of 150 minutes of physical activity per week are significantly less likely to have tinnitus ($p < 0.001$).

More specifically, an increase in vigorous-intensity leisure-time physical activity by one hour per week resulted in an 8% reduction in the risk of having tinnitus (OR = 0.923, 95%CI = 0.885-0.956, $p < 0.001$). Similarly, an increase in moderate-intensity leisure time physical activity by one hour per week resulted in a 6% reduction in the risk of having tinnitus (OR = 0.941, 95%CI = 0.907-0.981, $p = 0.002$). In addition, an increase in the IPAQ categorical physical activity score by one category was associated with a 23% decrease in the risk of having tinnitus (OR = 0.770, 95%CI = 0.598-0.981, $p = 0.039$). Participants who engaged in vigorous- and moderate-intensity physical activity for more than 150 minutes per week had a 50% lower risk of tinnitus (OR = 0.515, 95%CI = 0.384-0.687, $p < 0.001$). Table 1 presents the unadjusted and adjusted ORs of having tinnitus in relation to physical activity.

### *Sedentary behaviour and tinnitus*

Following adjustment for potential confounding factors, a significant association with having tinnitus was observed when sitting time exceeded 7 hours per day ($p < 0.001$). Specifically, individuals who sit for more than 7 hours per day had a 136% higher risk of having tinnitus (OR = 2.366, 95%CI = 1.743-3.248, $p < 0.001$). Table 2 displays the ORs for the association between sedentary behaviour and tinnitus, before and after adjusting for potential confounding factors.

## Discussion

This study investigated the relationship between physical activity level, sedentary behaviour, and the presence of tinnitus. The analysis showed that an increase in leisure-time vigorous- and moderate-intensity physical activity, total physical activity, and meeting the physical activity guidelines of 150 minutes per week were associated with a lower risk of having tinnitus. Additionally, prolonged sedentary behaviour, specifically sitting for more than seven hours per day, was associated with a significantly higher risk of tinnitus.

Based on these results it can be hypothesised that physical activity may act as a protective factor, and sedentary behaviour may be a risk factor for getting tinnitus. This hypothesis, though, assumes a causal relation between physical activity level and the risk of getting tinnitus. Due to the cross-sectional nature of our study we cannot be sure about the direction of the causality. This means it might also be possible that individuals with tinnitus engage in less physical activity and show more sedentary behaviour. This observed trend could potentially be attributed to the higher prevalence of obesity within the tinnitus patient cohort, heightened incidence of concomitant physiological symptoms, notably anxiety, stress, and depression (Figueiredo, Azevedo, and Penido 2016). Furthermore, this phenomenon may also be underpinned by the increase in tinnitus loudness that accompanies acute exercise in some patients, either during the exercise session itself or shortly thereafter (Michiels et al. 2019).

The current study results differ from those of Nondahl, et al. (Nondahl et al. 2011) who evaluated 3,267 participants between the age of 21 and 84 and found no correlation between self-reported exercise and presence of tinnitus (OR = 0.80, 95% CI [0.64, 1.01]) (Nondahl et al. 2011). This difference can be explained by the difference in outcome measure that is used to evaluate physical activity. In the study by Nondahl, et al. (Nondahl et al. 2011), the inquiry "Are you engaged in regular exercise?" was employed, whereas in our study, we used a questionnaire that has previously proven its reliability and validity and provides insight in different intensities and types of physical activity. Notably, the intensity and type of physical activity are pivotal factors influencing the risk of various health conditions, including tinnitus as shown by our current data. Interestingly, our findings are very similar to those of a study investigating the influence of physical activity on the incidence of major adverse cardiovascular events (MACE). Specifically, a recent investigation revealed an independent and inverse relationship between greater levels of leisure time physical activity and the incidence of MACE and all-cause mortality (Holtermann et al. 2021). Conversely, elevated levels of occupational physical activity were independently associated with an increased risk of MACE and all-cause mortality (Holtermann et al. 2021).

Furthermore, our novel findings present a notable contrast to the results obtained by Loprinzi, et al. (Loprinzi et al. 2013). In their study, a cohort of 963 adolescents aged 12 to 19 was examined, revealing no significant correlation between the duration of moderate-intensity physical activity and the presence of tinnitus (OR = 0.98, 95% CI [0.963, 1.008]; $p = 0.33$). Conversely, when investigating a sample of 340 older adults with hypertension, aged 70 to 85 years, Loprinzi, et al. (Loprinzi et al. 2013) did identify a significant association between low-intensity physical activity and the prevalence of tinnitus (OR = 0.996, 95% CI [0.992, 0.999]; $p = 0.02$). Particularly this disparity in findings may be attributed to differences in population age and the utilisation of accelerometers as a mean to assess physical activity. It is important to acknowledge that accelerometers, although valuable in capturing objective measures of physical activity, do not provide contextual information regarding whether the observed

activity is work-related or occurred during leisure time (Lynch et al. 2019)

In this study, sitting for more than 7 hours per day was associated with a higher risk of having tinnitus. To the authors' knowledge, this is the first study that evaluated the association between sedentary behaviour and tinnitus.

Currently, it is unclear how the level of physical activity can influence the risk of having tinnitus, but some hypotheses can be proposed. The inner ear is highly sensitive to changes in blood flow and oxygen supply, and reduced blood flow to the cochlea can damage the hair cells, leading to hearing loss and tinnitus ((Jafari, Kolb, and Mohajerani 2019)). On a higher level, physical activity has proven to increase the overall blood perfusion of the brain (Barnes 2015). A study of Zimmerman et al. (2021), who reported significant differences in global gray and white matter perfusion between tinnitus patients and controls (Zimmerman et al. 2021), highlights the importance of vascular health in patients with tinnitus and suggests that physical activity, which improves blood flow, could play a role in tinnitus prevention (Nystoriak and Bhatnagar 2018). Moreover, another study has shown that reduced tinnitus symptoms may be associated with increased frontal cortex activity in physically active individuals (Carpenter-Thompson, McAuley, and Husain 2015). This suggests that improved cognitive control in more active individuals could be a potential underlying mechanism. In addition, exercise can help to decrease the risk of hypertension (Hegde and Solomon 2015) and obesity (Silveira et al. 2022), whereas, sedentary behaviour is associated with an increased risk of hypertension (Gamage and Seneviratne 2021) and obesity (Silveira et al. 2022), all of which are risk factors for tinnitus (Figueiredo, Azevedo, and Penido 2016). Another possible mechanism by which physical activity may reduce the risk of tinnitus is the production of endorphins, which are suggested to reduce the perception of tinnitus (Biddle and Asare 2011; Sahley, Nodar, and Musiek 1999). Other potential pathways linking physical activity and sedentary behaviour to tinnitus include changes in inflammatory blood biomarkers. Chronic inflammation has been implicated in the development and progression of tinnitus (Szczepek et al. 2014; Weber et al. 2002). Physical activity may reduce the risk of getting tinnitus due to its anti-inflammatory effect (Chen and Nakagawa 2023; Falconer et al. 2014)

A notable finding in our study was the gender distribution among participants with and without tinnitus. Specifically, there were slightly more males among individuals with tinnitus, whereas the healthy control group had a higher proportion of females. Age was another significant factor in our study, with older individuals being more likely to have tinnitus compared to younger individuals. Most studies have found an increased prevalence of tinnitus with age and a higher rate in men (Baigi et al. 2011; Cho et al. 2010; Dawes et al. 2014; Engdahl et al. 2012; Hackenberg et al. 2023; Park et al. 2014; Park and Moon 2014). Despite this, a recent review and meta-analysis reported no difference in tinnitus prevalence between sexes but confirmed the increasing prevalence of tinnitus with age (Jarach et al. 2022)

. Furthermore, while our results may point towards a potential protective role of physical activity in getting tinnitus, it is crucial to emphasise that the current cross-sectional design does not allow for the establishment of a causal relationship. This is a first step towards future research investigating whether, physical activity can actually play a role in tinnitus prevention. Such a study would need long-term prospective follow-up of a large group of people without tinnitus at baseline, including physical activity monitoring but also monitoring of other factors, such as diet, that might play a role in tinnitus induction.

It must be noted that our study was conducted in a western-European population, and the results may differ if compared to other populations. Future studies could benefit from examining these associations in different populations. Additionally, we must stress that our study relies on self-reported data for assessing physical activity levels, as captured through the International Physical Activity Questionnaire (IPAQ). Self-reported data can introduce bias and inaccuracies, as participants may overestimate or underestimate their actual physical activity levels. Due to this limitation, conclusions made from our analysis need to be interpreted with some caution. Future studies should focus on employing objective measurement tools, such as accelerometers or fitness trackers, to gather more accurate and controlled data on physical activity levels. This would help to validate and potentially refine our findings by minimising self-reporting and recall bias and providing more robust insights into the impact of physical activity and sedentary behaviour on the risk of having tinnitus. Additionally, although our models were adjusted for several key tinnitus risk factors, including age, sex, hearing loss, noise trauma, noise exposure, and psychological symptoms (such as stress, anxiety, and depression), we did not account for other important variables like dietary habits, which may also influence a person's risk of getting tinnitus. This represents a limitation of our study that should be addressed in future research. Despite these limitations, this study is the first to provide evidence that lack of moderate to vigorous intensity leisure-time physical activity and sedentary behaviour may be linked to a higher risk of having tinnitus.

## Conclusion

In conclusion, this study provides evidence for the risk reducing effect of physical activity for having tinnitus and highlights the potential importance of reducing sedentary behaviour. These findings suggest that increasing moderate and vigorous leisure-time physical activity levels may play a role in the prevention of tinnitus. Future long-term prospective studies using objective measures for physical activity tracking and collecting data on other potential influencing factors are needed to confirm the importance of physical activity in tinnitus prevention.

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## Disclosure statement

No potential conflict of interest was reported by the author(s).

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