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Age-related hearing loss, depression and auditory amplification: a randomized clinical trial

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Abstract

Purpose Our study investigates the effectiveness of aural rehabilitation to decrease depressive symptoms in older adults, and the relationship between hearing loss and depression.

Methods A randomized controlled study was conducted at a hearing rehabilitation center with people over 65 years old. Participants were randomly allocated to the intervention group who received hearing aids, or to the control group. Data collection included pure-tone audiometry and a Portuguese version of the Geriatric Depression Scale assessed at two time points: baseline (P0) and after 4-week period (P1).

Results The results show that the increase of hearing thresholds in pure-tone audiometry is associated with a significant increase in depressive symptoms ($p = 0.001$). The effect of aural rehabilitation for improving depressive symptoms was significant in intervention group ($p = 0.000$) and between groups ($p = 0.003$) in P1.

Conclusion Age-related hearing loss has adverse effects on older adults' mental health, due to reduced hearing inputs that may increase levels of effort to communicate and affect social engagement, which lead to depression. Hearing aid use improves levels of depression and can promote greater quality of life in older adults.

Keywords Aging · Depression · Hearing aids · Hearing loss · Rehabilitation

Introduction

A growing body of evidence has shown that aging is the most common cause of hearing impairment and is referred to as age-related hearing loss (ARHL) [1]. ARHL results from pathologic processes associated with loss of hair cells at the basilar membrane, which leads to a progressive bilateral sensorineural hearing loss, that has a profound impact on older adult communication and daily functioning [2, 3].

It is known that hearing loss has negative consequences on physical functioning, mental health, and social relations. Recent studies have suggested that ARHL is strongly associated with depression in the geriatric population, revealing that ARHL gives rise to poorer quality of life, leading to increased prevalence of depression [4–8]. The mechanisms underlying this association are still unclear. However, they are thought to be a result of impaired communication and of the decrease of social engagement, affecting their ability to perform activities of daily life [9]. Kim et al. studied a group of subjects with hearing threshold ≥ 60 dB in both ears or ≥ 80 dB in one ear and ≥ 40 dB in the other [10]. The hearing assessment was performed with pure-tone audiometry (PTA) and auditory brainstem response (ABR), while depression was diagnosed using the International Classification of Disease. A strong correlation was observed between hearing loss and depression, independent of age and educational level. The conclusion drawn by the authors was that the severity of hearing disorder was associated with increased depressive symptoms in older people compared to other ages. Similar studies describe this

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relationship and Mulrow et al. corroborated the ARHL-depression association and suggested aural rehabilitation to treat the patients. The study concerned 188 older adults with hearing loss, in which half of the subjects were hearing aid users, with the findings showing that aural rehabilitation promoted social participation and decreased depressive symptoms in the hearing aid group [11].

These findings indicate the importance of early aural rehabilitation and provide support for use hearing aids as an effective treatment on older adults. Aural rehabilitation involves restoring the audibility of sounds to improve speech perception [9]. However, stigmatization and financial issues may contribute to low adoption rates for hearing aids in older adults.

In this context, studies have shown that older adults with hearing impairment, a greater number of depressive symptoms appear, which may be improved by hearing aids [10]. Possible mechanisms for improvement with the hearing aids have been proposed, suggesting that recovery of hearing audibility facilitates communication and enhance social relations, which decrease anxiety and depressive symptoms, contributing to well-being and thereby improving the quality of life of the older people [2]. Conversely, Mener et al. found that there was no relationship between ARHL and depression, and Pronk et al. showed similar findings, although revealed that ARHL was associated with increased loneliness in men after a 4-year follow-up [7, 12].

Such variations in findings produce limited evidence into this relationship, due to methodological differences in assessment and classification of ARHL and depression. Further, methodological assessment of hearing loss can be limited by use of self-reported hearing loss, conducting to contradictory results. Concomitantly, possible mechanisms for depression in ARHL determine the necessity of ongoing research to clarify equivocal findings and contribute to better understanding the etiology beyond this association, which could help to develop interventions that decrease the impact of ARHL on mental health. In addition, few studies have provided evidence that hearing aids improve health outcomes in older adults [13].

Therefore, the present study aimed to examine the association between depressive symptoms and ARHL, assessed with a pure-tone average (PTA) and a validated Portuguese version of the Geriatric Depression Scale (GDS) and verify the effectiveness of aural rehabilitation through the assessment of depression with GDS at baseline (P0) and after 4-week period (P1).

Materials and methods

The study was approved by the Ethical Committee of Polytechnic Institute of Coimbra in March 2018 (Approval number 2/2018). All the participants gave written consent prior to their participation, and the procedures applied were carried out in accordance with the Declaration of Helsinki. A total of 79 patients over the age of 65 years old with moderate sensorineural hearing loss were recruited at a specialized hearing rehabilitation center from a tertiary hospital after being referred to the ENT service. Study eligibility criteria specified moderate bilateral symmetric sensorineural hearing loss, based on a PTA of hearing thresholds at 0.5, 1, 2 and 4 kHz of 41 dB to 70 dB HL in better ear. Exclusion criteria included subjects with dementia, as defined by a score of ≤ 27 if participants had high school degree or more and ≤ 22 if had college or less on the Portuguese version of the Mini-Mental State Examination (MMSE). In addition, participants with prior use of hearing aids or abnormal otoscopy findings were excluded from the sample.

Eleven had cognitive impairment and seven of them use hearing aids, being excluded from the sample. As a result, the date from 61 subjects provided information were included in analysis. Informed consent was obtained prior to measurements.

Participants completed a full audiometric battery, including tympanometry, pure-tone audiometry, word recognition scores (WRS), performed with the Amplaid A756 model equipment and Aurical. Pure-tone thresholds were assessed through air conduction audiometry at 0.25, 0.5, 1, 2, 4, and 8 kHz and bone conduction pure-tone audiometry at 0.5, 1, 2, and 4 kHz. White noise was used for masking if applicable.

Word recognition score (WRS) for Portuguese monosyllabic words was assessed using Portuguese phonetically balanced words.

Depression was examined using the GDS Portuguese version. This is a self-reported scale containing 27 questions to detect depressive symptoms in the last 2 weeks. Subjects with a score of 11 or above are likely to be depressive [14]. Higher scores reflect more symptoms of depression.

Enrolled participants completed a standardized evaluation and according with simple randomization method, participants were randomly allocated into two groups after an independent audiologist generated the random allocation sequence using Qualtrics (Provo, UT, USA) software program. The study participants were not feasibly masked to randomization status. Thirty-two participants fitted with bilateral hearing aids of the same model (Receiver in the Ear Hearing Aid) and brand were included in the intervention group (IG), and 29 participants were assigned to control group (CG). The hearing intervention included hearing aids adjustment and control of the daily use through the processing algorithm built in hearing aids memory (mean time of 6 h of daily use). To the control group, no treatment was applied. The GDS was administered at two timepoints: baseline (P0) and after 4-week period (P1) to compare depression

symptoms between the groups and in pre- and post-treatment in each group.

All the participants in the research completed the study program.

Data management and analyses were performed using IBM SPSS Statistics 25. The results were analyzed with Students' test for paired and unpaired data and linear regression for correlations among variables such as age, better ear pure-tone average (BPTA), and educational level before aural rehabilitation. Statistical difference results were considered significant value at alpha level < 0.05.

Results

Demographic data

The sample was characterized by age, gender, education, marital status, better ear pure-tone average (BPTA), and depression symptoms (shown in Table 1). The mean age of the participants in the CG was 82.38 years old (SD = 6.99) and 77.47 in IG (SD = 7.93).

Data analysis

The two participants groups were compared in terms of sex, age, marital status, educational level, BPTA and GDS scores, using the independent samples *t* test. First, it was observed that the participants in CG had a significantly higher mean age than those in IG ($t = -2.555$; $p = 0.013$). Second, the study of the BPTA between the groups showed no significant difference ($t = 1.615$; $p = 0.112$). The participants in control group had a BPTA of 53.34 dB HL and those in intervention group of 56.95 dB HL.

Table 1 Participant descriptions

Individuals	*N* (%) or mean (SD)		*p*
	Intervention group	Control group	Between groups
Age	77.47 (7.93)	82.38 (6.99)	*0.013**
Gender			
Male	13 (40.60%)	14 (48.30%)	0.556
Female	19 (59.40%)	15 (51.70%)	
Marital status			
Married	20 (62.50%)	11 (37.90%)	0.321
Not married	12 (37.50%)	18 (62.10%)	
Education			
Nill	1 (3.10%)	9 (31.10%)	0.121
Elementary school	21 (65.60%)	14 (48.30%)	
Middle school	6 (18.80%)	5 (17.20%)	
High school	4 (12.50%)	1 (3.4%)	
GDS scores (P0)	10.63 (6.43)	11.69 (4.27)	0.296
GDS scores (P1)	6.94 (5.71)	10.97 (5.29)	*0.003**
BPTA	56.95 (9.58)	53.34 (8.47)	0.112

BPTA better ear pure-tone average, *GDS* geriatric depression scale
*$p < 0.05$

Pearson's correlation analysis was used for variables BPTA and GDS scores. A moderate correlation was found with increase of hearing thresholds associated with higher levels of depression ($R = 0.37$, $p = 0.03$).

The effect of hearing loss on depressive symptoms was then evaluated with a linear regression model, including age, marital status, education level, and BPTA. The regression model was designed using the GDS scores as the dependent variable and BPTA and other factors entered as covariates, such as age, marital status, and educational level. First, simple regression analysis was performed, with each of the independent covariates added separately. This univariable model is represented by GDS score $= \beta_0 + \beta_1 x_1 + \varepsilon$, where β_0 is the intercept, β_1 is the change in the score of GDS with each one of the covariates, and ε is an error term. The results shows that hearing loss has an independent association with depressive symptoms ($F(1.59) = 4.307$, $p = 0.08$; $R^2 = 0.385$), even after the effects of age ($\beta = 0.153$, $t = 1.241$; $p = 0.220$), marital status ($\beta = 0.171$; $t = 1.399$; $p = 0.167$), and educational level ($\beta = 0.196$; $t = 1.551$; $p = 0.126$) have been accounted for. The main predictive factor of depression was BPTA ($\beta = 0.289$; $t = 2.416$; $p = 0.019$).

To the subsequent analysis were performed a multiple regression with all covariables for the depression score in the multiple regression equation. The multiple regression equation was as follows: $y = 3.101 + 0.348x_1 + 0.105x_2 + 0.135x_3 + 0.270x_4 - 11.34$, where y is the predicted value of GDS scores, x_1 is the BPTA, x_2 is the participants age, x_3 is the marital status, and x_4 is the educational level. Adding all covariables together led to a significant improvement of the model ($p = 0.021$), and of the variance ($R^2 = 0.560$) (shown in Table 2).

To determine whether the treatment of using a hearing aid had any significant effect on depression, a Student's test for paired data analysis were performed (shown in Table 3). The scores obtained in the GDS revealed that there were significant differences between the evaluation and reassessment steps in IG ($t = 4.093$; $p = 0.000$). It could be observed that the older adults in IG showed fewer depressive symptoms after 1 month of use of hearing aids. In CG, no statistic differences were found between P0 and P1 ($t = 0.567$; $p = 0.454$). Analyzing the GDS results with Student's test for unpaired data, it was found that the mean of GDS scores in P0 was 11.69 in control group and 10.63 in intervention group. The average of GDS scores in P1 was 10.97 in controls and 6.94 in participants with hearing aids. The results showed that the IG improves depressive symptoms relative

Table 2 Results from the linear regression analysis

Depression score covariates	β coefficient (95% CI)	R^2
BPTA	0.289 (0.017; 0.317)	*0.385**
Age	0.153 (0,021; 0.361)	0.151
Marital status	0.171 (0.004;0.357)	0.167
Educational level	0.196 (0.005; 0.268)	0.126
BPTA + age + marital status + educational level	0.348 (0.097; 0.599)	*0.560**

β coefficient reflects the depression score change according with the covariables. R^2 is given as a measure of the goodness of fit of the model

BPTA better ear pure-tone average, *GDS* geriatric depression scale

*$p < 0.05$

Table 3 Student's test for paired data analysis to determine whether the treatment of using a hearing aid had any significant effect on depression, between the evaluation (P0) and reassessment (P1) steps in IC and CG

GDS scores	IG		CG	
	P0	P1	P0	P1
p	*0.000**		0.454	

GDS geriatric depression scale

*$p < 0.05$

to the control group, showed by the decrease in GDS scores that went from 10.63 in P0 to 6.94 in the final session of IG, and from 11.69 to 10.97 in CG. There was a significant difference between the GDS scores obtained between the groups under P1 condition ($t = -3.049$, $p = 0.003$).

Discussion

Our research has shown that ARHL influences the development of depressive symptoms even when other factors are considered. These results support the findings of West, who found that older adults with ARHL have a significant increase in depressive symptoms [15]. Previously, Cacciatore et al. studied 1332 subjects older than 65 years and found a strong correlation between hearing loss and depression [16]. Our findings suggest that a highly significant relation exists between hearing impairment and depressive symptoms, even after controlling sociodemographic factors that could explain this association. In addition, these previous studies used a methodological assessment of hearing loss that can be limited using self-reported hearing loss.

Furthermore, significant improvements have been found in depressive symptoms following the use of hearing aids, indicating that the effect of hearing loss on depression can be reversed with the use of this devices. These results support the findings of Castiglione et al., who assessed 125 older adults and compared the degree of hearing loss and the effectiveness of hearing aid use to in depression. The results showed that depressive symptoms occurred more often in participants with higher hearing thresholds. Reduction in depressive symptoms was also observed after the use of hearing aids. The conclusion drawn by the authors is that some factors influence this positive effect of aural rehabilitation, such as the of social isolation, the positive effect on neuroplasticity that reflects auditory training in working memory and reading ability, as well as improvement in self-motivation, self-esteem and self-confidence [17]. However, the study includes hearing-impaired with mild to profound hearing loss and, consequently, the selection of hearing aids was based on the degree of hearing loss, which can lead to variations in findings and produce limited evidence into this relationship. In our study, the inclusion criteria were specific about the degree of hearing loss, which allows that the IG received bilateral hearing aids of the same model and brand. The CG has not received treatment, therefore, results obtained suggest that the lack of auditory stimulation may be associated to increased social isolation, which leads to the depression that was maintained after a 4-week period. Therefore, we hypothesize that loneliness and social isolation may be related to depression in older adults and future research should try to address if there is a relationship between these variables.

Further, Boi et al. found that hearing aid has positive results in depression after 1 month of use, nevertheless at the end of 6 months, the level of depression was even lower, suggesting that these results can be maintained and even improved over time [18]. Our research corroborated that providing enhanced hearing inputs may lead to a decrease of levels of depressive symptoms, which can be related to the decrease of effort required to communication and facilitate greater social engagement.

Therefore, the results of present study further support the importance of early identification of age-related hearing loss and the effectiveness of aural rehabilitation as a treatment in the older population, to prevent mental health and improve quality of life. However, the mechanisms underlie this recovery are still unclear, our hypothesis suggests that improving hearing ability decreases loneliness and restores social participation, which in turn improves mental status.

Hence, it is suggested that future research using loneliness and socioeconomic status datasets should address the limitations of our study, and therefore, confirm or dispute our findings.

Conclusions

Hearing impairment can have significant adverse effects on the emotional state and social relations of older adults, leading to depression. Aural rehabilitation is a potential treatment to restore communication and is fundamental to decrease the risk of depression in older adults with hearing loss, which may improve quality of life, contributing for a healthy aging, with positive effects on cognition, mood and well-being.

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Declarations

Conflict of interest The authors declare that there is no conflict of interest.

Ethical approval The study was approved by the Ethical Committee of Polytechnic Institute of Coimbra in March 2018 (Approval number 2/2018).

Consent to participate All the participants gave written consent prior to their participation, and the procedures applied were carried out in accordance with the Declaration of Helsinki.

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