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PRESBYCUSIS AND DEMENTIA - OBSERVATIONAL STUDY WITH SAMPLE COLLECTION

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Abstract: **Introduction:** In Portugal in 2019, about 5,676 people died due to mental and behavioral disorders and regarding diseases of the nervous system and sense organs, which includes hearing loss, the number of deaths is about 4190, in both countries. genres. Presbycusis is an age-related hearing loss and its main characteristic is the difficulty in understanding words. Dementia is the generic term to encompass several diseases that affect cognitive abilities such as memory, which interfere with a person's behavior and more significantly with their ability to preserve their activities of daily living. This study is necessary to increase people's awareness of the increased prevalence of these two pathologies. Thus, it is of great relevance to the field of Audiology as it allows for the creation of a bridge between this field and that of Neuropsychology. **Goals:** The main objective of this study is to understand the relationship between age-related hearing loss (presbycusis) and the decline of cognitive functions, particularly memory. **Methods:** The methodology chosen for this project is observational, quantitative, descriptive, exploratory, bibliographic and field, and is transversal and prospective. The sample is composed of 21 individuals (7 males and 14 females), aged between 60 and 70 years, who mobilized to undergo audiological examinations at the Hospital das Forças Armadas – Polo Porto, or at the Centro Hospitalar. do Baixo Vouga, from May 1 to July 2, 2021. The assessment included the items: Tonal Audiometry and Montreal Cognitive Assessment (cognitive instrument). For this observational study, several variables were defined for the statistical analysis of the data obtained. **Results:** With the analysis of Figure 1, it can be seen that in the Moderate grades I and II a normal value of MoCA is not observed, however in the grades with less hearing loss (Normal and Mild) a value within the normal range is observed. With the interpretation of the graphs in Figures 2 and 3, it can be concluded that there is a higher prevalence of hearing loss in males (85.72%) than in females (78.57%). The analysis of the graphs in Figures 4 and 5 shows that there is no prevalence of mild cognitive impairment by gender, since the percentage is exactly the same as 71.43%. **Conclusions:** The results obtained show that presbycusis and changes in cognitive functions are related. It has been shown that the greater the degree of hearing loss, the greater the probability of alteration in cognitive functions.

Keywords: Presbycusis, Cognitive Ability, Memory, Hearing Loss.

INTRODUCTION

According to the National Institute of Statistics (INE), in Portugal in 2019, about 5,676 people died due to mental and behavioral disorders, a category that encompasses dementia and mental disorders, according to the International Classification of Diseases (ICD). also the results for diseases of the nervous system and of the sense organs, which covers hearing loss, with the number of deaths of 4190, in both genders (INE, 2021).

According to the National Health Survey 2014 (INS 2014), in Portugal 3.6 million people aged 15 or over reported having at least one physical and/or sensory limitation and 2.6 million individuals aged 15 or over years reported difficulty in hearing (INE, 2016).

The importance of studying various pathologies is of great relevance to increase health literacy and with the aim of increasing the quality of life of patients. In this project, only a few pathologies and concepts will be addressed, namely presbycusis, dementia and memory.

Presbycusis is present in people with age-related hearing loss and difficulty understanding words. They find it difficult to hear the high-pitched sounds of everyday

life, not being able to interpret the words spoken by other people, especially in noisy environments. The sensation of ringing in the ear (tinnitus), and the difficulty in hearing high-pitched sounds are also indicative symptoms of this pathology (WHO, 2013).

Dementia is the generic term to encompass various diseases that affect cognitive abilities such as memory, interfering with a person's behavior and more significantly with their ability to maintain their activities of daily living. It must be noted that dementia is not part of normal aging, although age is the strongest risk factor for its onset and subsequent development (Zillmer et al., 2008).

Presbycusis and dementia are of great interest today, and the aging of western populations is one of the most significant demographic events of the early 20th century. XXI. Therefore, this study is important to update the concepts using more current literature and it is necessary to increase people's awareness of the increased prevalence of these two pathologies, since they are related to aging. It is relevant to the area of Audiology as it allows creating a bridge between this area and Neurology. This project can be a starting point for them to come together in order to create a multidisciplinary team to intervene early in the diagnosis and treatment of these pathologies. It is estimated that 40% of people over 65 years of age have significant hearing loss that impairs communication and consequently reduces their quality of life (Monteiro & Subtil, 2009).

The motivations for choosing this topic are diverse, namely the personal one, since the researcher's maternal grandfather has dementia with evident hearing loss that has been observed for some years. This reason, together with the fact that a classmate had already developed a very comprehensive final project on this topic, triggered the curiosity to deepen the investigation in a more specific aspect, namely the cognitive function - memory, showing the negative impacts and global decays to be level of behavioral functioning. For this reason, the methodology chosen for this project is an observational, cross-sectional and analytical study, with collection and analysis of the data obtained, and subsequent discussion of the results.

The starting question of this study is whether "Is there any relationship between the decline in cognitive functions and age-related hearing loss?"

THEORETICAL FRAMEWORK

PRESBYCUSIS

Presbycusis is a symmetrical and progressive age-related sensorineural hearing loss (AP), manifested in the early stages by a difficulty in the perception of the most acute phonemes, that is, in the highest frequencies. The manifestation of this pathology begins in the fourth decade of life, but it is from the age of 80 that the peak incidence occurs, in which 50% to 80% of the elderly are affected. (Monteiro & Subtil, 2009; Schmiedt, 2010; WHO, 2013). According to the World Health Organization (WHO) points out that approximately one third of the population over 65 years old has hearing loss, it is estimated that by 2025, 1.2 billion people of the world population will be over 60 years old, in which more than 500 million of these people will suffer from presbycusis (Wang & Puel, 2020).

Presbycusis is conditioned by numerous environmental factors, such as smoking, noise, ototoxicity, trauma and infectious diseases, and is also influenced by several genes (polygenic phenomenon). Systemic diseases, such as hypertension, dyslipidemia and diabetes, caused by arteriosclerosis, trigger presbycusis, which are potentiated by internal factors of the person, such as genetics (Monteiro & Subtil, 2009; Wang & Puel, 2020).

Patients with presbycusis usually speak

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at a higher intensity (tone) than normal, complaining of lack of understanding of speech in noisy environments (decreased speech intelligibility), presence of tinnitus, noise intolerance and decreased of the dynamic field (Monteiro & Subtil, 2009; WHO, 2013).

It is estimated that 40% of people over 65 years of age have significant HL that impairs communication and consequently reduces their quality of life. With advancing age, the prevalence of HL also increases, above 65 years of age, progressive and disabling. Disabling BP is only considered when the mean tonal loss (mean air thresholds between 500 and 4 kHz), in the best ear, is greater than 40 dB HL (Monteiro & Subtil, 2009).

MILD COGNITIVE DEFICIT AND DEMENTIA

The marked aging of the population is a trend in all western industrialized countries. The pathologies associated with aging become a major concern, and the area of research is focused on understanding the neurological conditions that affect older people. Within these characteristics, we are faced with a group of pathologies, collectively known as dementias, which cause global declines in cognitive and behavioral functioning. The etiologies of these diseases are not yet known and are not associated with a single cause, but with multiple causes (Zillmer et al., 2008).

Mild cognitive impairment is a transitional state between normal cognitive aging and dementia, and an early cognitive assessment is essential in order to minimize the negative impact on the patient's life (Nasreddine et al., 2005).

Dementia is often progressive and affects numerous higher mental components, and there is still no cure for most of these dementias. It is dubbed a "mind thief" as it first "steals" an aspect of cognition, such as memory, visual and spatial skills, or communication skills, but then relapses again to take away other factors of mental functioning (Zillmer et al, 2008).

HEARING LOSS, PRESBYCUSIS AND DEMENTIA

In sensorineural systems, the auditory system is essential for a broader and deeper understanding of neurodegenerative diseases. Presbycusis is a sensorineural hearing loss, where there is a progressive and bilateral degeneration of the hair cells of the cochlea. It is a symmetric and irreversible deafness characterized by the lack of understanding of words, difficulty in locating the sound source and the appearance of tinnitus. According to Wang & Puel, (2020), there is a higher prevalence of presbycusis in males than in females. The classification of the International Bureau for Audiophonologie (BIAP), (1997), classifies the AP according to the degree, as indicated in the table in Annex 1. In patients with AP, cortical activity is characterized by adaptive plasticity and neuronal reorganization. Several anatomical changes occur as a compensation mechanism, namely, increased neural activity, synaptic degeneration and cortical atrophy. Thus, early intervention in both the diagnosis and auditory rehabilitation of presbycusis can prevent social isolation, depression and dementia. It is predicted that in the next forty years the prevalence of dementia will double every twenty years, the impact that presbycusis has on dementia is evident and it is very important to take advantage of the opportunities that hearing rehabilitation (AR) makes available, such as cochlear implants, hearing aids and listening support systems (Monteiro & Subtil, 2009; Wang & Puel, 2020).

HEARING REHABILITATION

In general, all patients diagnosed with AP, of all age groups, must be followed up and

rehabilitated as early as possible. AR's main objectives are to improve safety, autonomy, quality of life and family and social integration. The first step in AR is the audiological assessment of the patient, the perception of the need to use acoustic amplification devices, to carry out a rehabilitation plan. It is essential in this program to contain a variety of hearing aids suitable for your hearing loss, and there must be a personalized follow-up to clarify any doubts and maximize the success rate of using the hearing aid (Monteiro & Subtil, 2009).

MEMORY

Memory is a dynamic and malleable process of updating memories, not necessarily being an accurate representation of past events. This can be explained as a system of encoding, storing and retrieving information about external and internal stimuli. A past memory is susceptible to interference, that is, the retrieval and manifestation of a memory may undergo modifications (Jahn, 2013; Lee et al., 2017; Zillmer et al., 2008).

Memory is implicit in most aspects of human experience. The way each one sees himself, to a large extent, is the result of life lessons and experiences, and what he remembers as important. The plans and tasks that we propose to do in the future are also included in the memory. Neural resources needed for memory storage can be enriched or depleted by psychological and physiological states, strengthening or weakening memory (Lee et al., 2017; Zillmer et al., 2008).

Cognitive functions, such as memory, verbal fluency, knowledge and reasoning, processing speed, and sensory functions (auditory and visual acuity) are affected by aging, showing an uninterrupted decline in these. Regarding memory, it is not possible to quantify it as good or bad, it is divided into systems based on notions of storage and processing. In many pathologies, as is the case with most dementias, head injuries, toxic conditions and oxygen loss, memory processing is compromised as it is a "fragile" system (Pereira, 2018; Zillmer et al., 2008).

MEMORY SYSTEMS

Over time, with the advancement of science and studies in the field of Neuropsychology, memory has undergone various categorizations defined by different authors in the field of Neurology, which also have different neuroanatomical and neurophysiological correlates. Thus, the convergence of data from neuropsychology, neuroimaging, molecular biology and clinical neurology support the concept of clinically distinct memory systems: episodic memory, semantic memory, procedural memory and working memory (Matthews, 2015).

EPISODIC MEMORY

Episodic memory, encompassed in declarative and explicit memory, stores specific events or experiences, usually autobiographical, or referring to a certain context that requires temporal and spatial references. This type is the most affected with advancing age, which in turn is the first memory to decline in Alzheimer's disease (AD) and to be detected and perceived as dysfunctional by both patients and their families. This episodic memory dysfunction can present as acute (concussion), transient (transient global amnesia), subacute (thiamine deficiency), or chronic (AD) (Matthews, 2015; Papalia & Duskin, 2013).

SEMANTIC MEMORY

The term semantic memory is a subtype of declarative and explicit memory, it refers to the storage of historical facts, meaning of words, social customs, that is, everything that encompasses factual knowledge,

which is independent of a space and time. Thus, semantic memory does not require a recollection of where and when something was learned. It is the type of memory that is least affected with aging, undergoing few changes, and certain characteristics such as knowledge of language rules and vocabulary can be enriched. The brain structures most commonly associated with semantic memory loss are the anterior and inferior temporal lobe (Papalia & Duskin, 2013; Zillmer et al., 2008).

PROCEDURE MEMORY (PROCEDURAL)

Procedural memory is a subtype of non-declarative implicit/explicit memory, it is one of the memory systems that is irrelevantly affected with advancing age. It includes the learning and retention of a variety of motor skills, habits and processes such as cycling, reading and writing, once learned do not require conscious effort to be recalled and activated. Thus, procedural memory contains an automatic component and does not involve conscious recall of learning (Matthews, 2015; Papalia & Duskin, 2013; Pereira, 2018).

WORK MEMORY

Like semantic and episodic memory, working memory is a type of explanatory and declarative memory, but generally speaking it is a component of executive function. Working memory refers to the retention of short-term functions while processing, such as doing calculations. It is characterized by the active maintenance of verbal and non-verbal information in the brain to complete goal-directed tasks and procedures (Matthews, 2015; Papalia & Duskin, 2013).

The following table exemplifies some types of memories, the deficits they may present in neurological tests, and the pathology associated with that memory deficit.

METHODOLOGY

STUDY CHARACTERIZATION

This project follows a type of research in terms of observational nature, in terms of the descriptive quantitative approach, in terms of exploratory objectives, in terms of bibliographic and field technical procedures, and is transversal and prospective in terms of development over time (Fontelles et al., 2009).

GOALS

The starting question is "Is there any relationship between the decline in cognitive functions and age-related hearing loss?". The objectives of this study are:

- Understand whether there is a relationship between the degree of hearing loss (PTM) and the results obtained in the MoCA cognitive screening instrument;
- Understand whether the increase in the degree of hearing loss is associated with the change in the results obtained through the MoCA;
- Find out if there is a prevalence of hearing loss between genders.
- Understand whether there is a relationship/prevalence of the results obtained in the MoCA with gender.
- Contribute to raising awareness of the importance of carrying out hearing and cognitive tests, for the early diagnosis of pathologies in these areas;
- Raise awareness of the need for effective early auditory rehabilitation in individuals with presbycusis.

SELECTION OF PARTICIPANTS

The sample consists of all patients between 60 and 70 years of age, who were referred for audiological examinations, at Hospital das Forças Armadas (HFAR) – Polo Porto, or at Centro Hospitalar do Baixo Vouga (CHBV),

Type of memory	Deficit in cognitive tests	associated neuropathology
Episodic (declarative, explicit)	Verbal: oral narrative recall, word list recall (Wechsler Memory Scale Word List I and II) Visual: collection of the copy of the figure, collection of the location of the figure in the space	Alzheimer's disease, thiamine deficiency, hippocampal sclerosis, hypoxic-ischemic encephalopathy, dementia with Lewi bodies
Semantics (declarative, explicit)	General knowledge background, image designation, category fluency	Alzheimer's disease
Work (declarative, explicit)	Digit range, mental arithmetic	Dementia with Lewi bodies, Parkinson's disease, traumatic brain injury
Procedure (non-declarative, implicit/ explicit)	Not routinely tested	Parkinson's disease, cerebellar degeneration, Huntington's disease

Table 1 - Clinically relevant memory systems; Matthews, B.R. (2015). Modified and adapted table.

Inclusion criteria	To be a prosthesis/cochlear implant user
Patients who are seen at the ENT service of the HFAR or CHBV during the study period	Being a prosthesis/cochlear implant user
Patients between 60 and 70 years old	Presence of other neurological diseases
Patients with normal hearing or mild or moderate hearing loss	Patients who do not sign the informed consent
Patients with sensorineural hearing loss (type)	Patients with hearing loss induced by pathologies of the outer and/or middle ear

Table 2 - Sample selection criteria

Independent Variables	Dependent Variables
Gender (Male/Female)	**MoCA – Cognitive Capacity:** • Mild Cognitive Deficit: 0 – 25 values • Normal cognitive ability: 26 – 30 values
Age (60 to 70 years)	
Moderate Grade I: Normal Light Moderate grade I Moderate grade II	

Table 3 - Variables considered in the observational study

between May 1 and July 2, 2021, and meet all inclusion/exclusion criteria.

SELECTION CRITERIA

The sample for this project must meet certain criteria (Table 3).

VARIABLES

For this observational study, several variables were defined to define hypotheses and consequently obtain results, respective discussion, and conclusions (Table 2).

PROCEDURES AND MATERIAL

Prior to the implementation of the protocol, the patients were duly informed of the details of the study and signed an informed consent. For patients who agreed to participate in the study, the sociodemographic variables from the clinical record were collected. The study protocol consists of pure tone audiometry (AT) and MoCA in the Portuguese version (M. Simões et al., 2007).

The materials used for data collection were: two Interacoustics® AC40 brand and model Audiometers for TA and a MoCA model sheet, in the experimental version in European Portuguese (Annex 2), together with an administration guide so that all examiners can explain it equally and homogeneously, so as not to interfere with the completion of the MoCA.

INSTRUMENT - MONTREAL COGNITIVE ASSESSEMENT

The Montreal Cognitive Assessment (MoCA) is a screening tool for mild cognitive impairment (MLD). The MoCA is easy to apply and understand, in which it assesses: memory, executive function, language, visuospatial ability, calculation, attention and concentration, abstract reasoning, and orientation. The execution time varies between 10 to 15 minutes, the maximum score is 30 points, and the normal score is equal to or greater than 26 points. For some years, adjustments were made to its structure, namely in terms of punctuation and reduction of domains. The final version of the MoCA stands out as a quick, effective and practical method for distinguishing between healthy cognitive aging and DLB in the elderly. This instrument consists of a page and an instruction manual for the examiner (Carson et al., 2018; Fonseca, 2015; García Reyes, 2013; M. R. Simões et al., 2008).

In the diagnosis of dementias, screening instruments are essential, therefore, they must contain a lot of sensitivity to assess DLB. Compared to the Mini Mental State Exam (MMSE), the MoCA was developed more recently and several studies show that this test has greater sensitivity and specificity to detect a mild cognitive deficit (Fonseca, 2015; Rambe & Fitri, 2017).

ETHICAL ISSUES

The request for the Guidance Statement was sent to the supervisor and co-supervisor with the intention of signing it, so that the advisee could obtain follow-up during all phases of the final degree work (Annex 3).

Authorizations to carry out the research project were requested from HFAR and CHBV, but so far no response has been received. As a commitment of honor, this study will not be published without prior authorization from the Ethics Committees of the aforementioned hospitals (Appendices 4 and 5).

All participants in this study were asked to provide a Free and Informed Consent Form from both hospitals, so that they could understand all their involvement in the study (Appendices 6 and 7).

During the entire process of data collection and analysis, patients' anonymity and confidentiality were maintained.

STATISTICAL ANALYSIS

In this study, data analysis is performed using a descriptive statistics program – IBM Statistical Package for the Social Sciences (SPSS) Statistics, version 27.

In order to study the sample, descriptive statistics were used, and the qualitative variable Gender, Degree of hearing loss (PTM) and MoCA are described through a table of absolute (n) and relative (%) frequencies. The quantitative variable Age e was described through measures such as the mean ($x_{\bar{}}$), the standard deviation (± SD) and its maximum and minimum value.

For the analysis of the collected data, we used the construction and analysis of bar and circular graphs in order to relate to the proposed objectives.

RESULTS

SAMPLE CHARACTERIZATION

The sample consists of 21 patients, 14 (66.7%) are female and 7 (33.3%) are male. Regarding the MoCA variable, it is categorized into Normal and Mild Cognitive Deficit, according to the classification of the authors of this cognitive instrument, in which 28.6% of the sample has a value within the normal range and 71.4% has a DCL. For the degree of bilateral hearing loss, the PTM was categorized according to the BIAP (1997). It is observed that 4 patients have normal hearing; 12 have mild PA; 4 have moderate AP grade I, and finally 1 has moderate AP grade II. As for the quantitative variable age, the mean is 65.86 years and its standard deviation is 2.37, where the youngest participant is 61 years old and the oldest is 70 years old (Table 4).

Regarding the objectives "Understand if there is a relationship between the degree of hearing loss (PTM) and the results obtained in the MoCA cognitive instrument" and "Perceiving if the increase in the degree of hearing loss is associated with the decrease in the results obtained through the MoCA ", a bar graph was made (Figure 1), for categorical variables.

With the analysis of the graph below (Figure 1), it can be seen that in the Moderate I and II levels a normal value of MoCA is not observed, however in the degrees with less hearing loss (Normal and Mild) a value within the normality. This refers to the existence of a relationship between the degree of hearing loss and the results obtained in the cognitive instrument MoCA. Therefore, the second objective is confirmed since there is a slight indication that the increase in the degree of hearing loss is associated with the decline of cognitive functions, studied by the MoCA instrument.

With the interpretation of the graphs in Figures 2 and 3, it can be concluded that there is a higher prevalence of hearing loss in males (85.72%) than in females (78.57%). It can also be concluded that in this age group, regardless of gender, there is a higher incidence of mild hearing loss, 50% in females and 71.43% in males.

The analysis of the graphs in Figures 4 and 5 shows that there is no prevalence of mild cognitive impairment by gender, since the percentage is exactly the same as 71.43%.

DISCUSSION AND CONCLUSION

In this last chapter, we will proceed to the discussion and conclusion of the results obtained, in which critical reflections will be elaborated on them in order to compare them with the studies of the literature found, and to deduce whether defined objectives were achieved. Some limitations found during the study will be addressed, and how to turn this investigation into an analytical and explanatory research.

With the results obtained, it seems to prove that presbycusis and changes in cognitive functions are related. It has been

N = 21			
Género	Female Male	14 7	66,7% 33,3%
MoCA	Normal Mild Cognitive Deficit	6 15	28,6% 71,4%
Degree of Hearing Loss Bilateral	Normal Light Moderate I Moderate II	4 12 4 1	19,0% 61,9% 14,3% 4,8%
Age	65,86 ± 2,372 (Min = 61; Máx = 70)		

Table 4 - Characterization of qualitative and quantitative variables

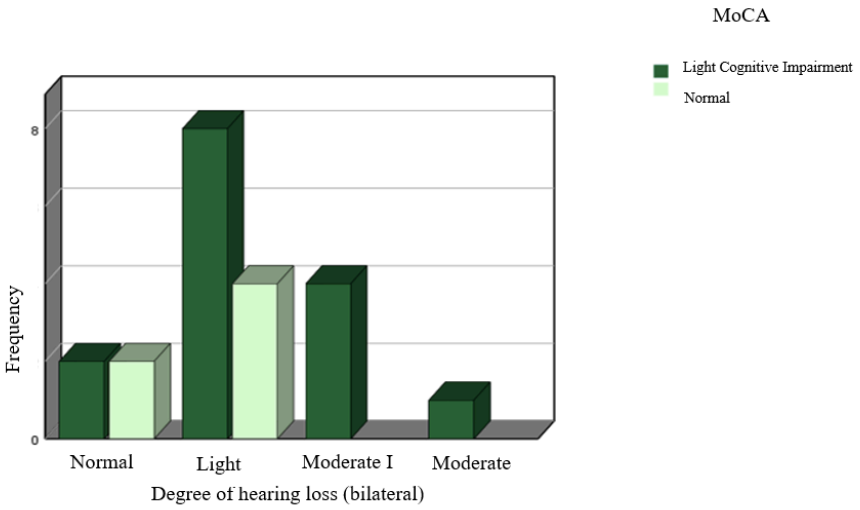

Figure 1- Bar graph comparing the degree of hearing loss with the MoCA result

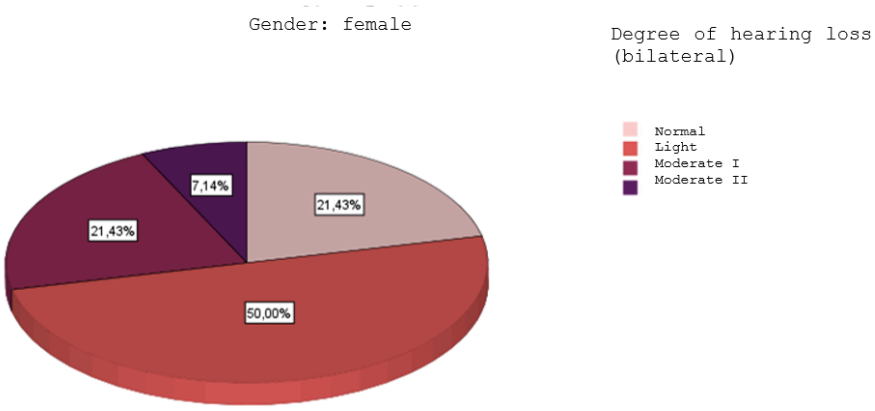

Figure 2 - Degree of Hearing Loss in Females

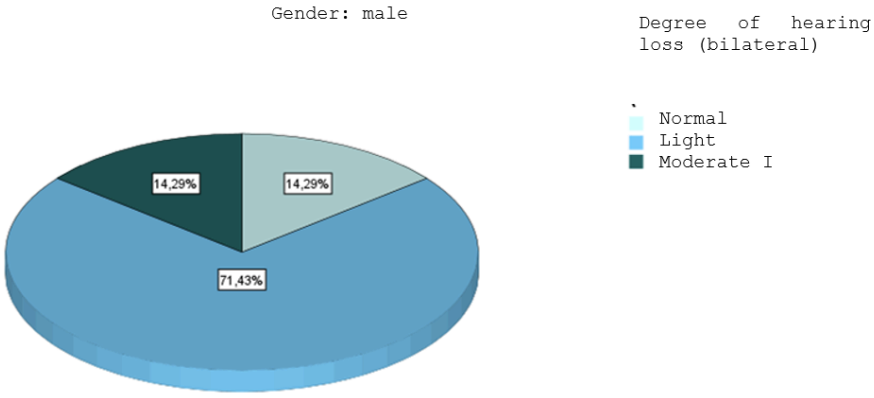

Figure 3 - Degree of Hearing Loss in Males

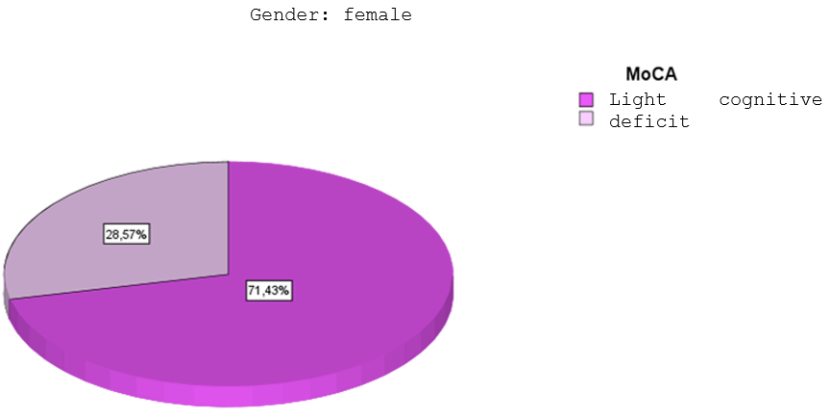

Figure 4 - MoCa versus female gender

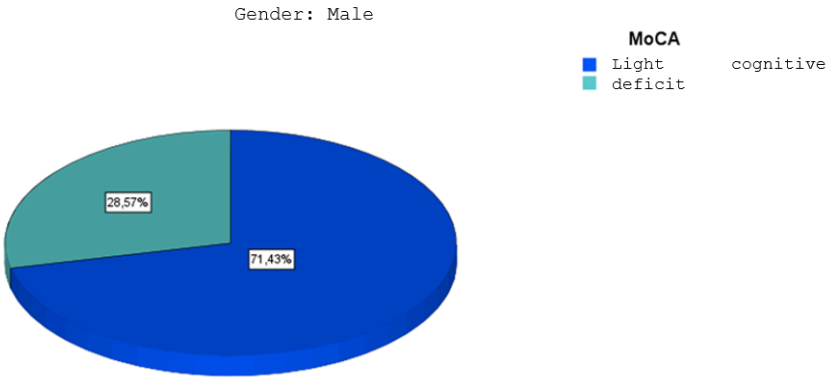

Figure 5 - MoCa versus male gender

shown that the greater the degree of hearing loss, the greater the probability of alteration in cognitive functions. According to the bibliographic review and meta-analysis by Loughrey et al., 2018, which brought together 36 epidemiological studies and 20,264 participants, it was found that there is a reduced, but significant, association between age-induced hearing loss (presbycusis) and the decay of cognitive functions, increased risk of cognitive impairment and incidence of dementia. However, it was found that for Alzheimer's disease and vascular dementia the increases in risk were not significant. It was also found that the greater the hearing loss, the worse the cognition. It concluded that there are multiple risk factors for the decline of cognitive functions, presbycusis is one of these factors due to the fact that there is a decrease in auditory discrimination, affecting episodic and semantic long-term memory and in turn the memory of work is the least altered (Loughrey et al., 2018). As Wang & Puel, (2020) found, with the analysis of the sample of this study, it is concluded that there is a higher prevalence of hearing loss in males than in females (Wang & Puel, 2020).

In this study, the MoCA test was used, as in the study by Nasreddine et al., 2005, which indicates that it is a test with great sensitivity and excellent specificity. In the analysis of the results of this project, in the comparison between genders and the result of the MoCA, it was found that there is no prevalence between males and females (Nasreddine et al., 2005).

With this study, the objective will be to minimize the factors for DLB, such as presbycusis, in order to improve the quality of life of patients over 60 years of age.

Given the fact that the sample was collected in a short period of time and due to the exclusion factors, it becomes reduced (N=21), and not homogeneous in terms of gender (Female = 14 and Male =7).

With what was proposed in this work, despite the limitations found, it was possible to relate presbycusis with the decline of cognitive functions. As a result, the earlier we diagnose presbycusis and encourage awareness of the harmful effects that hearing loss can cause on a daily basis, promoting auditory rehabilitation.

For the development of future studies, it will be essential to increase and homogenize the sample so that an analytical and explanatory quantitative study can be carried out to transpose it to the Portuguese population in general.

This project aroused curiosity for the development of the theme, this initial analysis can be a starting point to lead to several studies and in particular one that allows to relate patients with presbycusis without auditory rehabilitation with patients with presbycusis and hearing rehabilitated and the results of the MoCA instrument.

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