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Review

The social problem of presbystasis and the role of vestibular rehabilitation in elderly patients: a review

Il problema sociale della presbistasia e il ruolo della riabilitazione vestibolare nell'anziano: una revisione della letteratura

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SUMMARY

The term "presbystasis" refers to a common clinical condition in the elderly, characterised by a multifactorial and progressive impairment of balance. The pathophysiology may be related to various concomitant factors including central nervous system diseases, peripheral neuropathy, osteoarticular disorders (leading to a reduction of the speed gait), and cardiovascular or visual disorders, but it may also be a consequence of deficits of the peripheral or central vestibular system (which is generally represented by a bilateral and symmetric vestibular dysfunction). Benign paroxysmal positional vertigo (BPPV) is far from being rare in subjects over the age of 70 years. Nowadays, presbystasis represents one of the main causes of accidental falls in the elderly, leading to a reduction in quality of life and life expectancy. The aim of our work was to review the current literature on presbystasis, focusing on the role of the vestibular system in the pathogenesis and on the possibilities offered by vestibular rehabilitation in the management of these subjects. Other clinical conditions related to the disorder are also discussed.

KEY WORDS: dizziness, frail elderly, accidental falls, postural balance, rehabilitation

RIASSUNTO

Il termine presbistasia si riferisce a una condizione di comune riscontro negli anziani, caratterizzata da un progressivo e multifattoriale disordine dell'equilibrio; la fisiopatogenesi può originare dalla concomitanza di diversi fattori, tra i quali patologie del sistema nervoso centrale, da una neuropatia periferica, disordini osteoarticolari (che provocano una riduzione della velocità di marcia), patologie del sistema cardiovascolare e visivo, ma può anche avere come concausa deficit del sistema vestibolare periferico e centrale; soprattutto la Vertigine Parossistica Posizionale Benigna (VPPB) è comune nei soggetti di età superiore a 70 anni. La presbistasia rappresenta oggi una delle principali cause di cadute negli anziani e ha come conseguenza una riduzione dell'aspettativa e qualità di vita. Scopo del nostro lavoro è stato quello di rivedere la recente letteratura focalizzandoci sul ruolo del sistema vestibolare nella patogenesi e sulle possibilità terapeutiche offerte dalla riabilitazione vestibolare. Sono state inoltre riassunte nella review le altre concause del disturbo.

PAROLE CHIAVE: *instabilità, anziano fragile, caduta, equilibrio, riabilitazione vestibolare*

Introduction

The term presbystasis refers to age-related functional modification in structures related to equilibrium, including the vestibular system. Dizziness and vertigo in older patients frequently have a multifactorial aetiology [1,2]. In particular, the term "dizziness" indicates a condition of impaired balance and is one of the main causal factors of falls in an advanced age. In addition, aging of the peripheral and central vestibular system can lead to a chronic disequilibrium and to an increased risk of falls [1].

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Balance disorders in the elderly represent a significant problem of utmost importance within society. In fact, an increase in their frequency with aging, especially in the very old, leads to a remarkable increase in falls with consequent increases in healthcare costs. In navigation tasks, three cues play a role, namely vision, proprioception and the vestibular system, with the latter being a sensor of self-movement for both linear and angular acceleration and also acting as a graviceptor. All the three cues are involved in the disorder, while the peripheral and central nervous systems, musculoskeletal system, medications and other factors often play a substantial role. In many instances, subjects do not report a true vertigo due to peripheral vestibular disorders, and it is likely that these are cases of dizziness due to presbystasis [2]. Recent studies have highlighted that 20%-30% of persons experience episodic dizziness in a 12-month period. This percentage dramatically increases in older people and in women. In those over 80 years, the prevalence of dizziness is reported to be more than 80% [3,4]. In the US, every year about 7.5 million patients access an emergency department or outpatient clinic for dizziness and vertigo [5-7]. In a survey on dizziness in elderly in the US, around 20% of over 65 subjects reported a problem with dizziness or imbalance in the preceding 12 months [8]. In another survey, the authors reported that most dizzy subjects over 65 years were evaluated by different specialists, who administered therapies with diuretics and benzodiazepines with poor results; moreover, imaging and other clinical exams did not correlate with more tailored therapy [9].

In older people, chronic dizziness increases the risk of accidental falls with a subsequent decrease in the quality and expectancy of life. According to the Prevention of Falls Network Earth (ProFaNE), falls are defined as an unexpected event in which subjects come to rest on the ground, floor, or lower level. The incidence of falls is 30-60% per year in the elderly with subsequent injuries, hospitalisation, or even death in 10-20% of cases [1]. Moreover, the clinical consequences of accidental falls in older patients represent an important cause of mortality and have high management costs in US and Europe [1,10]. In the US, the costs of falls exceed $ 20 billion yearly [11,12]. The risk of falls significantly alters the quality of life in the elderly and the fear of falling greatly reduces their activities [13]. Moreover, dizziness and subsequent fear of falling are correlated to depressive status and reduction in self-autonomy and self-control, with subsequent functional disabilities and social isolation [4,13,14]. In patients aged over 70 years, vestibular dizziness occurs in 15%, whereas non-vestibular dizziness occurs in 20%-70% [13,15-18]. The aim of this work is to review the current literature on presbystasis, focusing on the role of the vestibular system in the pathogenesis of the disorder and on the possibilities offered by vestibular rehabilitation in the management of these subjects.

Materials and methods

A review of the literature was performed on different databases including PubMed and SCOPUS according to the "Preferred Reporting Items for Systematic Reviews and Meta-analyses" (PRISMA) guidelines, as summarised in Figure 1. We used the following strings: "Presbystasis", "Dizziness in Elderly", "Vestibular Impairment in Elderly", "Balance Disorders and Elderly". A total of 12,596 original articles were found. Only articles published from 2000 and in English were considered, and only those with keywords Dizziness\Vestibular Impairment\Balance Disorders AND Elderly were included.

Results

A total of 95 publications were obtained and after critical evaluation 45 were included in the review (Fig. 1).

Non-vestibular and multifactorial presbystasis

Several publications underline that dizziness in the elderly is a multifactorial disorder. Central nervous system diseases of different origin, such as cerebrovascular pathologies, parkinsonism, Alzheimer's disease and dementia, may contribute to a decreased equilibrium, causing dizziness and an increased risk of falls by impairing control of critical functions [1,19,20]. Loss of fine muscle control, postural imbalance, involuntary movements, and prolongation of reaction time usually play a destructive role in terms of balance disorders and dizziness.

Psychogenic disorders such as anxiety and depressive syndrome are often correlated with dizziness [19,20]. They sometimes represent a comorbidity in patients affected by peripheral vestibular dysfunction, while in others they may cause or be caused by a state of dizziness. Clinical assessment and in-depth investigation of these conditions is crucial to better characterise the patient.

Cardiovascular diseases, such as hypertension, orthostatic hypotension and atrial fibrillation [1], by impacting regulation of blood pressure and oxygen supply to the brain, are frequently involved in dizziness and feeling slightly off balance. Being frequent in older patients, these conditions may be controlled by daily control and appropriate therapeutic actions. Postural hypotension, above all, is strongly associated with a risk of falls and may occur due to dehydration, medications and autonomic neuropathy. Therefore, many authors underline that management of postural hypotension should be considered to reduce the risk of falls [21-24].

Progressive vision worsening with aging due to several physiological modifications in visual acuity, contrast and glare sensitivity, dark adaptation, accommodation, and depth perception also plays an important role [25-29]. Moreover, in older adults the risk of developing pathologies such as cataracts, glaucoma, and macular degeneration is

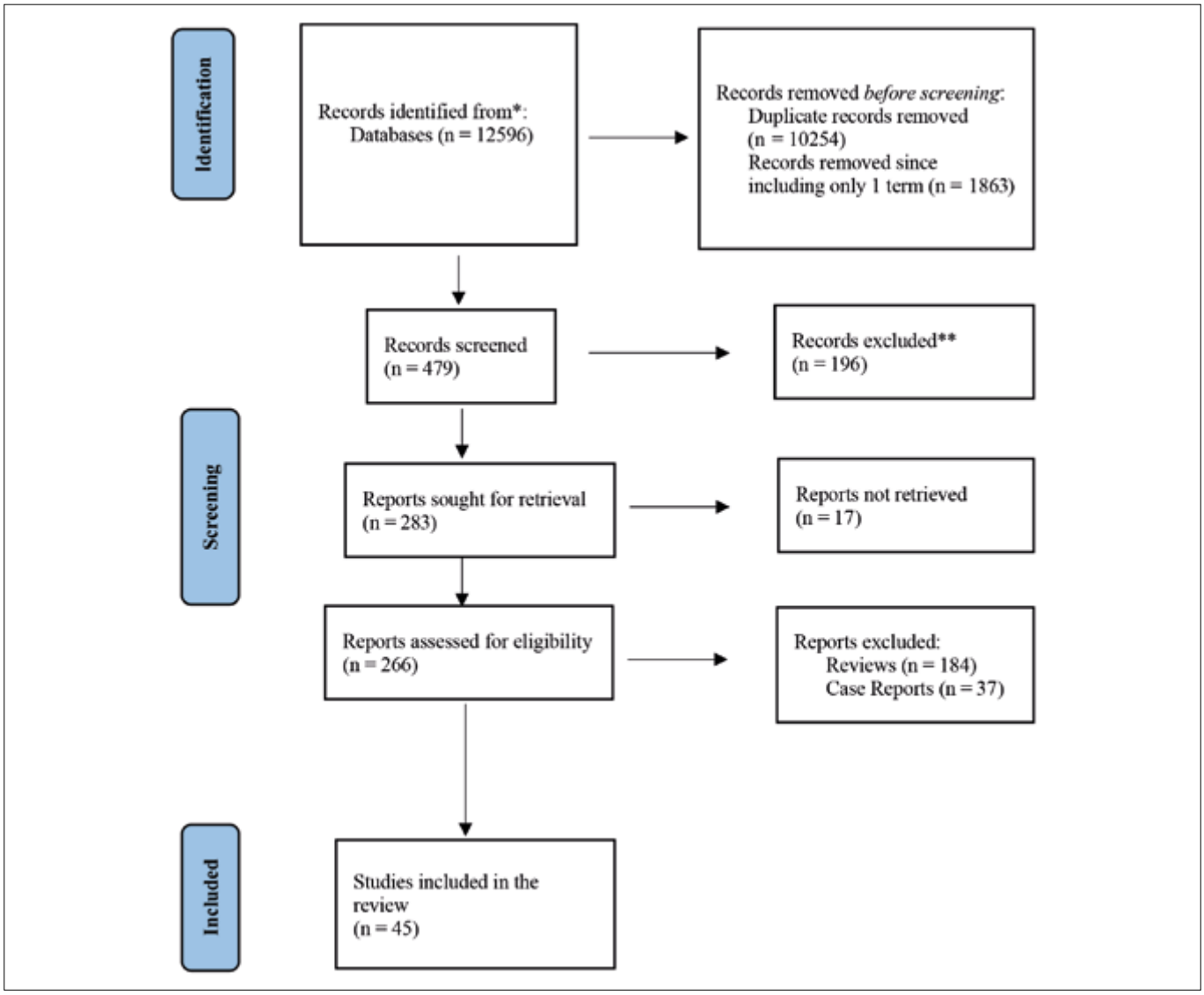

Figure 1. Search strategy flowchart. * 1985; ** for duplication.

increased. The elderly suffering from hypertension and diabetes mellitus often present an increased risk of retinopathy. Essentially, visual impairment leads to the patient to misunderstand spatial information, distances and edge of images with increased risk of imbalance and falls [30,31]. In patients with visual disorders, vision should be always assessed and these should be treated [21].

Different classes of drugs can have an impact on equilibrium. In fact, depending on their direct activity or possible toxic effects, medications may cause somnolence, reduce attention threshold, decrease peripheral nervous perception (affecting both exteroception and proprioception) and impair muscular strength. Among others, antidepressants, anxiolytics, antipsychotics, some antibiotics, chemotherapy and anticholinergic drugs can be involved [1]. Since medications have been linked to a high risk of falls in older people, discontinuation or, if not possible, dose reduction, is recommended, in particular for psychotropic drugs [21].

Proprioception disorders such as peripheral nerve impairment due to alcoholism, diabetes mellitus, vitamin B12 deficiency, chemotherapy and osteoarticular diseases such as arthritis and spondylosis may also play a role [30].

Armstrong et al. showed that in older patients there is a high prevalence of multisensorial impairment, involving not only vision and hearing but also the vestibular system, leading to increased disability overall [32].

Moreover, the role of genetic factors in presbystasis has been hypothesised, as in presbycusis [5]. Results on non-vestibular contributions in presbystasis are summarised in Table I.

Presbystasis of vestibular origin

Peripheral vestibular dysfunction is one of the most frequent causes of dizziness in the elderly [especially benign paroxysmal positional vertigo (BPPV), Menière's disease, and vestibular neuritis] [33,34]. The most common cause of vertigo and dizziness is represented by BPPV [15,35] and it has been demonstrated that otoconial degeneration and fractures occur with aging. Regarding vestibular neuritis,

Table I. Multiple disorders contributing to presbystasis reported in publications underlying non-vestibular causes.

Author	Sample numerosity	Performed tests	Clinical condition	Results\intervention\conclusions
Gleason et al., 2009 [19]	172	Mini mental scale (MMSE)	Dementia	Minimal decrements of MMSE correlated with increased risk of fall
Muir et al., 2020 [20]	Meta-analysis of 21 publications	Performed tests	Different subsystems	Increased risk of fall
American Geriatric Society, 2011 [21]	Meta-analysis	-	Vision impairment Postural hypothension Cognitive impairment	
Tinetti et al., 1994 [22]	301	Full medical assessment	Postural hypotension; use of sedatives; use of at least four prescription medications; impairment in arm or leg strength	Multiple-risk-factor intervention strategy resulted in a significant reduction in the risk of falling
Close et al., 1999 [23]	184	Full medical assessment	Postural hypotension; use of sedatives; impairment in arm or leg strength	Multiple risk factors intervention leads to a decreased number of falls
Davison et al., 2005 [24]	128 fallers 100 case controls Both 75 years or older Matched for other comorbidities	24 hours ECG	49% (63) of recordings in fallers and 41% (41) of recordings in controls were abnormal	Increased risk of fall in subjects with ECG abnormalities
Lord et al., 1991 [25]	95 (mean age 82)	Vision, vestibular, proprioceptive tests Stabilometry	Vision, vestibular, proprioceptive, muscoloskeletal	Proprioceptive, visual and muscoloskeletal disorders mainly correlated with presbystasis
Clark et al., 1993 [26]	81 (mean age 83)	Full medical examination with an attention on cardiovascular, respiratory, neurological, gastrointestinal, haemopoietic, genitourinary	Cardiovascular, respiratory, neurological, psychiatric	Impaired cognition, abnormal reaction to any push or pressure, history of palpitations were predictive for falls
Jack et al., 1995 [27]	200	Full visual examination	Vision	Fallers have a high prevalence of visual impairment
Lord et al., 1992 [28]	50	Six tests of sensorimotor function Use of psychoactive drugs	Proprioception Drugs use	27% of fallers had poor proprioception Psychoactive-drug use was associated with falling
Nevitt et al., 1989 [29]	325 (age over 60)	Clinical history	Proprioception Neurological disorders	Multiple risk factors increase risk of falls
Zetterberg, 2015 [31]	Review	Visual examination	Vision	Increased presbystasis in subjects with visual impairment
Armstrong et al., 2021 [32]	-	Hearing, vision, olfaction, proprioception, and vestibular function		Multiple sensory impairment correlated with risk of fall
Kannus et al., 2005 [45]	Review	Multiple interventions		Suggested regular exercise, vitamin D and calcium supplementation, withdrawal of psychotropic medication, cataract surgery

vestibular compensation in the elderly can be lacking or ineffective due to decreased vestibular function of the intact side, visual function and proprioception.

A vestibular ocular reflex (VOR) gain impairment in older people has been demonstrated with several methods, especially caloric and rotational tests, head thrust test, and cervical and ocular vestibular evoked myogenic potentials (cVEMPs – oVEMPs). In the elderly, c- and oVEMPs have decreased amplitude and increased latency. Studies with posturography demonstrated a decreased balance control in this group due to decreased function of the above-mentioned systems. Moreover, some studies have highlighted cellular loss in vestibular organs [15]. In addition to otoconia fragmentation and loss of hair cells in cristae ampullaris of semicircular canals and maculae of saccule and utricle, decreased vascularisation of the inner ear, vermian atrophy, and a reduction in the number of vestibular nuclei in neurons and cerebellar Purkinje cells have been described in association with aging [1,2].

Interestingly, Biju et al. showed in a recent publication that the vestibular system plays an important role in fall risk of patients suffering from Alzheimer's disease and, in particular, that better semicircular canal function is linked to a lower risk of falls [36,37].

Results in vestibular contributions in presbystasis are summarised in Table II.

Non-vestibular and vestibular rehabilitation in presbystasis

A multidisciplinary diagnostic-therapeutic programme and physiotherapy are necessary to improve rehabilitative results and quality of life in non-vestibular-related dizziness, and seem to be more effective than medical therapy [13,38-40]. Vestibular rehabilitation represents an effective tool in disorders such as presbystasis and post-labyrinthitis vestibulopathy and should be performed at least 3-4 times per week. Modifications in therapy are also an important strategy, such as discontinuing antihistamines, anticholinergic drugs and benzodiazepines [2].

Physical exercises may vary on a case-by-case basis depending on the patient's disorder (unilateral or bilateral peripheral vestibulopathy) and symptoms (imbalance, vertigo, oscillopsia, fear of falls, nausea and anxiety), even though most rehabilitation programmes commonly involve eye and head movements. Moreover, rehabilitation is reported to be more effective in unilateral vestibulopathy than in bilateral cases [41].

Some recent studies on vestibular rehabilitation in older Parkinson subjects have demonstrated its effectiveness [42]. Moreover a Virtual Reality system, which can also be used

Table II. Studies reporting vestibular contributions in presbystasis.

Author	Sample numerosity	Performed tests	Clinical condition	Results\intervention\conclusions
Tuunainen et al., 2011 [34]	38	Vestibular tests Mini Mental Scale (MMSE)	Vestibular deficits were present in the large majority of subjects	Progressive loss of balance is a disorder involving vestibular, system, oculomotricity, visual acuity and proprioception
Lindell et al., 2021 [35]	55	Full vestibular testing	Vestibular deficits	40 subjects were fallers, 11 presented a BPPV
Biju et al., 2022 [36]	-	Full vestibular tests	Comorbidity for Parkinson's disease	Better semicircular canal function was significantly associated with lower likelihood of falls
Teggi et al., 2017 [37]	58	Video-head impulse		Decrease of vestibulo-oculomotor reflex gain in the elderly. The decrease of canal function may therefore play a role in the risk of falls in the elderly
Tuunainen et al., 2013 [46]	55	Rehabilitation	Presbystasis	Reduced risk of falls
Socher et al., 2012 [38]	12	Rehabilitation	Menière's disease	Effective in improving quality of life and risk of falls also in subjects over 80
Gomes Patatas et al., 2009 [39]	22	Rehabilitation	Dizziness	Effective in improving quality of life and risk of falls even in subjects over 80
Brito et al., 2021 [41]	111 elderly	Rehabilitation	Dizziness	Improve of instability, DHI questionnaire and quality of life
Abasi et al., 2022 [42]	11 elderly with Parkinson's disease	Rehabilitation	Dizziness	Positive effects on oculomotor function and balance
Zak et al., 2022 [43]	Elderly with frailty syndrome fall risk	Rehabilitation with virtual reality	Dizziness	Effective in bringing in desirable therapeutic outcomes

DHI: dizziness-handicap-inventory.

at home, has been demonstrated to be useful in the treatment of elderly with presbystasis [43].
Results on rehabilitation are summarised in Table III.

Discussion

Balance disorders, in particular presbystasis, are frequent conditions, especially in elderly patients. Dizziness and imbalance may have several causes; in many cases, its multifactorial pathogenesis is due to impairment of several systems, and in particular the vestibular, visual, nervous and musculoskeletal systems [15,44].
Impairment of the somatosensory system is correlated with aging due to static and dynamic muscle spindle modifications, reduction of Pacini and Meissner's receptors, plantar tactile sensitivity, joint position perception, lower limb weakness, and reduction in strength and speed, with subsequent extension of reaction time; moreover, in the elderly there is also a modification in gait that is slower, shorter and wider compared to younger subjects [30].
Therefore, multifactorial fall risk assessment and intervention is advisable [21].
Prevention of falls is crucial to prevent injuries and consists of balance training, vitamin D and calcium supplementation, reduction of psychotropic drugs, cataract surgery and individual home-hazard assessment [45].
As mentioned above, the psychological condition of the patient should also be assessed, since psychogenic disorders such as anxiety may be associated.
While geriatric studies have been published mainly in the years around 1990-2000, some recent investigations have focused on the vestibular contribution in instability in the elderly, using recently introduced diagnostic tools such as video-head impulse test and video-Frenzel. The role of a vestibular disorder in these subjects has likely been underestimated in past works and a vestibular examination is necessary in routine evaluation in our opinion.
Presbystasis in older subjects generally involves bilateral and symmetric vestibular dysfunction found at vestibular examination. Further clinical manifestations of presbystasis can be slowed gait and reduced response to sudden motion [2].
Tuunainen et al. described four variants of loss of balance with aging, called "presbyequilibrium", through analysis of clinical findings with posturography and video-oculography:

- episodic presbyvertigo syndrome: episodic vertigo provoked by physical activity and cases of BPPV;
- postural presbyequilibrium: postural instability with positional and gravity-dependent worsening;
- frail syndrome: decrease in muscle strength and coordination, need for assistance, continuous dizziness and falling sensation;
- autonomic vertigo syndrome: syncope, near-syncope and floating sensation with positional changes, linked with a high risk of falls [46].

Vestibular rehabilitation is often effective even in subjects with comorbidities for neurological disorders and modification in medical therapy may also be warranted.

Table III. Studies reporting results about the role of vestibular rehabilitation.

Author	Sample numerosity	Age (years)	Type of rehabilitation	Results
Socher et al., 2012 [38]	12	35-86	Five sessions of vestibular rehabilitation	Significant improvements in DHI scores for all aspects
Gomes Patatas et al., 2009 [39]	22	16-87	Two-three times daily for at least six weeks	All the DHI scores reduced significantly after vestibular rehabilitation; general improvements in the quality of life after customised vestibular rehabilitation
Sulway et al., 2019 [40]	-	-	-	Vestibular rehabilitation improves symptoms of imbalance, falls, fear of falling, oscillopsia, dizziness, vertigo, motion sensitivity and secondary symptoms such as nausea and anxiety
Brito et al., 2021 [41]	113	60-88	Immersive virtual reality-based sensorimotor rehabilitation, three times a week for 6 weeks	The immersive virtual reality-based sensorimotor rehabilitation is a useful tool in elderly patients, that can lead to a reduction of symptoms associated with mental disorders
Abasi et al., 2022 [42]	11	65.16 (mean age)	Vestibular rehabilitation for 24 sessions (3 sessions per week)	Positive effects on oculomotor function and balance
Zak et al., 2022 [43]	-	-	-	Modern technologies (virtual reality) in frail patients may complement the traditional model of rehabilitation by enabling to return to the pre-frail stage, simultaneously enhancing both motor and cognitive function

DHI: dizziness-handicap-inventory.

Correct management should include an adequate rehabilitative programme in addition to quality of life assessment. In fact, rehabilitation is largely used to improve postural stability and quality of life perception in elderly patients suffering from multifactorial dizziness [13].

Finally, in the COVID-19 era, the possibility to perform rehabilitation with a physiotherapist may be troublesome in the elderly, since hospital access may be limited. New devices have been proposed to make home rehabilitation possible and to avoid a hospital setting, and some are already available; we believe that this may be the future for rehabilitation of older people, not only for its efficacy on presbystasis, but also for its positive effects on emotion [41]. A medical device for home rehabilitation (fHIT-R2, Be-On Solutions©) has been recently commercialised in Italy. The software, through a series of accelerometers, allows the home execution of exercises with the aim to increase vestibulo-oculomotor and vestibulo-spinal function as well as spatial memory. Exercises can be performed at home by the patient and the software allows the operator to check the proper execution of the exercises.

The rehabilitation programme must be targeted to the patient's disorders and symptoms, even though it can be difficult to be followed by elderly people. Given the social burden of presbystasis, physicians should pay greater attention to improving management of balance disorders.

Conclusions

Presbystasis is a common complaint in the elderly, leading to consistent emotional consequences. More often multisensorial deficits including vestibular, metabolic, neurological, visual, musculoskeletal and cardiovascular disorders play a role in dizziness. A balance of these different pathophysiological causes should be made and when possible they should be treated. In subjects with multisensorial deficits, rehabilitation has been demonstrated to be useful, also acting on the emotional component.

Conflict of interest statement

The authors declare no conflict of interest.

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Author contributions

RT: manuscript writer; MF, RAB, OG, IC: articles research; MB, LB: supervision of the manuscript and validation of research.

Ethical consideration

This study was approved by the Institutional Ethics Committee of San Raffaele hospital for a larger study on dizziness (protocol number 104/INT/2020).

The research was conducted ethically, with all study procedures being performed in accordance with the requirements of the World Medical Association's Declaration of Helsinki.

Written informed consent was obtained from each participant/patient for study participation and data publication.

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