AGE (2013) 35:2315–2327
DOI 10.1007/s11357-012-9494-7

Vestibular rehabilitation in elderly patients with central vestibular dysfunction: a prospective, randomized pilot study

Gino Marioni · Salvatore Fermo · Marco Lionello · Elena Fasanaro · Luciano Giacomelli · Stefania Zanon · Claudia Staffieri · Franco Dall'Igna · Enzo Manzato · Alberto Staffieri

Received: 12 July 2012 / Accepted: 9 November 2012 / Published online: 22 November 2012

Abstract For the vestibular system, aging is associated with degenerated otoconia and loss of hair cells, vestibular afferents, and cells in the vestibular nuclei. Further neurodegenerative processes involve cortical, extrapyramidal motor, and cerebellar structures. Dizziness is quite common in the elderly, limiting their mobility and activities. The role of vestibular rehabilitation in these patients is controversial. The present prospective, randomized, preliminary investigation aimed to compare the effect of a 6-week posturography-assisted vestibular rehabilitation protocol (30 min a week) combined with a home-based exercise program (group A, 14 randomly assigned elderly patients) with the same home-based exercise program alone (group B, 14 randomly assigned elderly patients) for treating dizziness due to central vestibular dysfunction in elderly patients. The outcomes were analyzed using the 25-item Dizziness Handicap Inventory (DHI) and computerized posturography. After rehabilitation, group A scored significantly better in the DHI for the functional ($p=0.0016$) and emotional ($p=0.01$) domains and total score ($p=0.001$); only the emotional domain improved significantly in group B ($p=0.038$). Group A improved significantly in some posturographic parameters in the motor tests (reaction time, movement velocity, and endpoint excursion),

G. Marioni (✉) · S. Fermo · M. Lionello · E. Fasanaro · A. Staffieri
Department of Neurosciences, Otolaryngology Section, University of Padova,
Via Giustiniani 2,
35128 Padova, Italy
e-mail: gino.marioni@unipd.it

M. Lionello
Department of Otorhinolaryngology, Plastic, Aesthetic and Reconstructive Head and Neck Surgery,
University Hospital of Würzberg,
Würzberg, Germany

L. Giacomelli · E. Manzato
Department of Medicine, DIMED, University of Padova,
Padova, Italy

S. Zanon
U.O. Gravi Cerebrolesioni Acquisite, Ospedale Riabilitativo Motta di Livenza,
Motta di Livenza, Italy

C. Staffieri
Department of Neurosciences, Otolaryngology Section Treviso Branch, University of Padova,
Treviso, Italy

F. Dall'Igna
University of Padova,
Venezia Branch, Italy

E. Manzato
CNR, Aging Section, Institute of Neurosciences,
Padova, Italy

while group B experienced more limited improvements. Our preliminary results with a program of posturography-assisted vestibular rehabilitation, and home-based exercises are more promising than with home-based exercises alone. A new study on a larger series of elderly patients with central vestibular dysfunctions is currently underway at Padova University, considering the effect of a protocol involving rehabilitation with computerized posturography alone and the relationship between outcomes and the duration of rehabilitation programs.

Keywords Central vestibular disorder · Elderly patients · Vestibular rehabilitation · Computerized posturography · Home-based exercise program

Introduction

Aging adversely affects sensory function, sensory motor processing, and musculoskeletal efficiency. For the vestibular system in particular, aging is associated with degeneration of the otoconia and hair cells, loss of vestibular afferents, and declining numbers of cells in the vestibular nuclei (Furman et al. 2010). The elderly are also liable to other (cortical, extrapyramidal motor, and cerebellar) neurodegenerative processes (Jahn et al. 2010). Sensory function is, therefore, usually altered in elderly people, and information arriving from the sensory end organs is often processed erroneously by the central nervous system (Suarez et al. 2003). Dizziness is quite common in older people, restricting their mobility and activities (partly for fear of falling) and interfering with their quality of life (Jahn et al. 2010). Falls associated with dizziness in the elderly can be a cause of morbidity, mortality, and medical costs (Kao et al. 2010). About 30 % of people over 65 years old who live at home fall at least once a year (Jahn et al. 2010).

Vestibular rehabilitation is now widely used in the management of patients with peripheral vestibular disorders (Hillier and McDonnell 2011), and Eleftheriadou et al. (2012) reported that age did not influence the outcome of vestibular rehabilitation in patients with chronic vertigo due to peripheral vestibular impairments. Little is known, however, about how patients with an impaired central vestibular function [from 7 to 45 % of diagnoses in tertiary balance and vestibular clinics in the USA (Brown et al. 2006)] respond to specific rehabilitation programs (Badke et al. 2004), particularly when they are elderly. The present prospective, preliminary study aims to compare the effectiveness of two protocols of vestibular rehabilitation (posturography-assisted vestibular rehabilitation combined with a home-based exercise program versus home-based exercise program alone) over the body balance control on elderly people with central vestibular dysfunction. The results were analyzed using both computerized posturography (sensory and motor tests) and the 25-item Dizziness Handicap Inventory (DHI) presented by Jacobson and Newman (1990) for assessing the self-perceived debilitating effects of vestibular system disorders.

Methods

Trial design

The present is a preliminary, single-center, prospective, randomized (1:1 ratio) study conducted in accordance with the 1996 Helsinki Declaration. The investigation was approved by our Otolaryngology Section's internal ethical committee, and written informed consent was obtained from all participants prior to any study-related procedures.

Eligibility criteria for participants

Our inclusion criteria were as follows: evidence of central vestibular dysfunction on videonystagmographic evaluation (ICS Chartr 200, GN Otometrics A/S, Taastrup, Denmark) (which included analyzing spontaneous and positional nystagmus, the Dix–Hallpike maneuver, quantitative and qualitative measures of smooth pursuit and saccades, and Fitzgerald–Hallpike caloric tests); no evidence of unilateral vestibular weakness or benign paroxysmal positional vertigo; age of >65 years; no impairment on otoscopic/otomicroscopic evaluation; a pure tone threshold bilaterally consistent with the patient's age; and a normal visual acuity with or without corrective lenses.

All patients underwent magnetic resonance imaging and/or computerized tomography of the brain, and neurological evaluation. Exclusion criteria were any diagnoses of musculoskeletal disorders, Parkinson's disease or dementia, or treatment with anticonvulsant, antidepressant, hypnotic, strong analgesic, or muscle-relaxing medication.

Study setting

The study took place at the Otolaryngology Section (academic tertiary referral center) of the Neurosciences Department, Padova University, Italy.

Interventions

Fourteen patients were randomly assigned to vestibular rehabilitation assisted by posturography (VSR System, Neurocom International Inc., Clackamas, OR) supervised by an otolaryngologist and a trained physiotherapist (in weekly sessions lasting approximately 30 min for 6 weeks) plus a home-based exercise program as previously described by Guidetti (1997) (see Figs. 1, 2, 3 and 4), which was repeated three times a day for 6 weeks (group A); the other 14 patients only completed the same home-based exercise program (group B). Using the custom training option in the VSR System, the otolaryngologists and the physiotherapist showed group A patients how their body movements influenced the cursor's movement on the screen (Fig. 5). The preferred posturography-assisted training program is described in detail in the appendix to this paper. All patients received verbal and written instructions concerning the exercises to perform at home, and they were strongly advised to complete the exercises under supervision and in a space cleared of any objects that might be harmful. Information regarding home-based exercises execution was collected through an interview at last control.

Outcome measure

The patients in both groups underwent diagnostic computerized posturography before starting rehabilitation (T0) and again 6 weeks later (T1). The following tests were performed in all cases:

A. Sensory testing with the modified Clinical Test of identify abnormalities in the sensory system's three contributions to postural control (vestibular, visual, and somatosensory). The mCTSIB measures the center of gravity (COG) sway velocity (in degrees per second) under the following four conditions: eyes open/firm surface, eyes closed/firm surface, eyes open/foam surface, and eyes closed/foam surface. Each trial lasted 10 s, and three trials were conducted for each condition;

B. Motor testing with the Limits of Stability (LOS) to quantify several movement characteristics associated with a person's ability to sway voluntarily to various locations in space and briefly remain stable in said positions. During this test, the location of the subject's COG was displayed on a screen as a cursor, providing visual feedback, and subjects controlled the cursor by shifting their weight. To perform the test, they had to lean quickly and accurately to make the cursor coincide with targets that were also displayed on the screen. The parameters measured were reaction time (RT, the time in seconds between the signal to move and when the individual started to move); movement velocity (MVL, the average speed of displacement of the COG, in degrees per second, between 5 and 95 % of the distance to the primary endpoint); endpoint excursion (EPE, the distance traveled by the COG on the first attempt to reach the target, expressed in %LOS); maximum excursion (MXE, the furthest distance traveled by the COG during the trial); and directional control (DC, a comparison between the amount of movement in the intended direction and the amount of extraneous movement). DC was calculated as follows:

$$\frac{(n-m)}{n}$$

with n=amount of intended movement and m=amount of extraneous movement.

It was expressed as a percentage. Each trial lasted 8 s, and there were eight targets (forward, forward right, right, backward right, backward, backward left, left, and forward left).

The 25-item Dizziness Handicap Inventory was administered to all patients before and after their rehabilitation programs. The purpose of the scale is to identify difficulties that people may experience because of dizziness or unsteadiness. Patients answer each question as "yes" (4 points), "no" (0 points), or "sometimes" (2 points), and higher scores (maximum 100 points) are associated with a more severe self-perceived handicap. The DHI items are grouped into three content domains representing functional (F, nine questions), emotional (E, nine questions),

Fig. 1 Point de Mire. Stare at a point approximately 3 m away and, while doing so, rotate your head laterally (yaw) for 1 min (**a**), bend the head laterally (roll) for 1 min (**b**), and extend and flex the head (pitch) for 1 min (**c**). Patients repeat the exercise sitting and standing

Fig. 2 Stand 4 cm away from a wall in the four positions shown. Patients can move on to the next position if they do not touch the wall for 10 s with their eyes open and for 20 s with their eyes closed

Fig. 3 Standing 4 cm away from a wall, extend your arms and walk in the four directions shown with your eyes open for 10 s and closed for 20 s

and physical (P, seven questions) aspects of dizziness and unsteadiness (Jacobson and Newman 1990).

Purpose

The endpoint of this preliminary study was to compare the effectiveness of two protocols of vestibular rehabilitation (posturography-assisted vestibular rehabilitation combined with a home-based exercise program versus home-based exercise program alone) over the body balance control on elderly people with central vestibular dysfunction.

Fig. 4 Walk on a soft surface for approximately 1 min with your eyes open and your arms extended while staring at a point approximately 3 m away. Patients repeat the exercise with their eyes closed

Sample size

The current preliminary study considered comprehensively 28 elderly patients strictly homogeneous for clinical and videonystagmographic diagnosis of central vestibular dysfunction without associated peripheral vestibular disorders. Fourteen patients were randomly assigned to vestibular rehabilitation plus a home-based exercise program (group A); 14 patients completed only the same home-based exercise program (group B). Considering the 25-item Dizziness Handicap Inventory as the main outcome, mean values, and standard deviations of the two groups at the baseline and after treatment and fixing $\alpha=0.05$ (one sided), $\beta=0.86$, correlation between the two measurements $r=0.70$, number of patient ratio=1, the number of patients to be allocated to each group in a new confirmatory experiment should be 47 cases.

Randomization: sequence generation

Patients were assigned to one or other group by a person uninvolved in their recruitment according to a computer generated randomization list.

Randomization: type

Randomization sequence was created using the SAS 6.12 (SAS, Cary, NC) and was stratified by center with a 1:1 allocation.

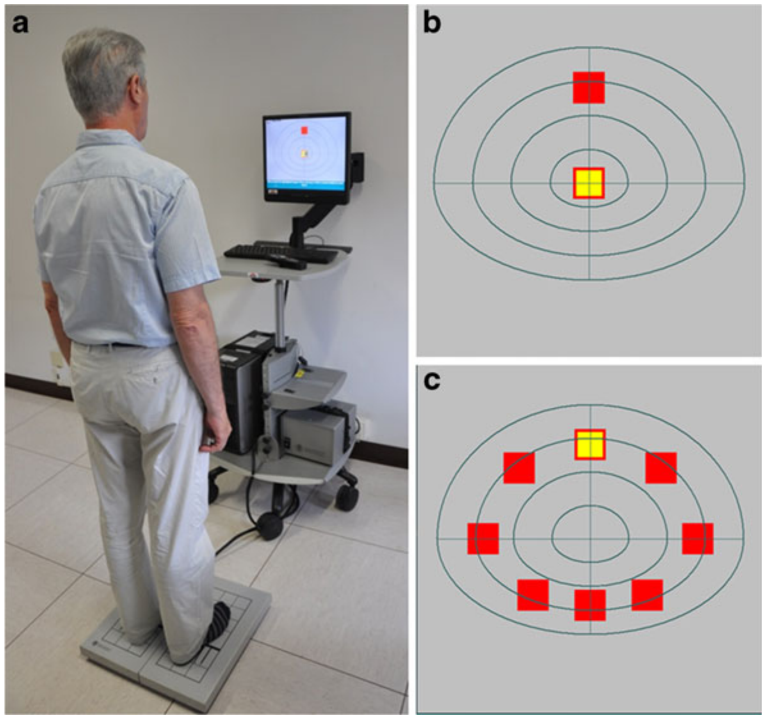

Fig. 5 Rehabilitation protocol involving computerized posturography (**a**). Detail of targets displayed on the screen, **b** center to anterior to center and **c** circling to right (clockwise)

Statistical methods

The statistical significance of the differences between the mean findings was ascertained using Wilcoxon rank sum test to compare within-group results and the Mann–Whitney test on pooled data to compare between-group findings. A p value of less than 0.05 was considered significant. The STATA 8 statistical package (Stata Corp., College Station, TX) was used for all analyses.

Results

Participant flow

The participant flow was summarized by a diagram according to Consolidated Standards of Reporting Trials 2010 (www.consort-statement.org; Fig. 6). Fourteen patients (six males and eight females, mean age 73.9± 8.0 years) were randomly assigned to posturography-assisted vestibular rehabilitation combined with a home-based exercise program (group A), and the other 14 patients (eight males and six females, mean age 74.4± 7.3 years), only to the home-based exercise program (group B). All the patients enrolled completed the study. No adverse events potentially attributable to the vestibular rehabilitation programs were recorded.

Baseline (T0) findings

On brain magnetic resonance imaging and/or computerized tomography, the picture was normal in 15 patients, while microangiopathy was identified in eight, and mild senile changes (brain atrophy), in five. In group A, the median baseline DHI scores were F=10 (mean 13.4±8.4), E=10 (mean 11.1±9.3), P=12 (mean 11.1±6.2), and total=32 (mean 35.7±20.7), while in group B, they were F=14 (mean 12.4±8.3), E=11 (mean 11.4±7.4), P=9 (mean 9.3±4.9), and total=35 (mean 33.1±17.2). The Mann–Whitney test on pooled data ruled out any significant differences between the two groups' mean (F, E, P, and total) DHI scores at the baseline (p=0.92, p=0.66, p=0.53, and p=0.90, respectively).

At baseline computerized posturography (T0), there were no significant differences between groups A and B in the sensory tests (mCTSIB) under the four conditions considered (eyes open/firm surface, eyes closed/firm surface, eyes open/foam surface, and eyes closed/foam surface) (Mann–Whitney test, p=0.11, p=0.31, p=0.10, and p=0.64, respectively). Table 1 summarizes these

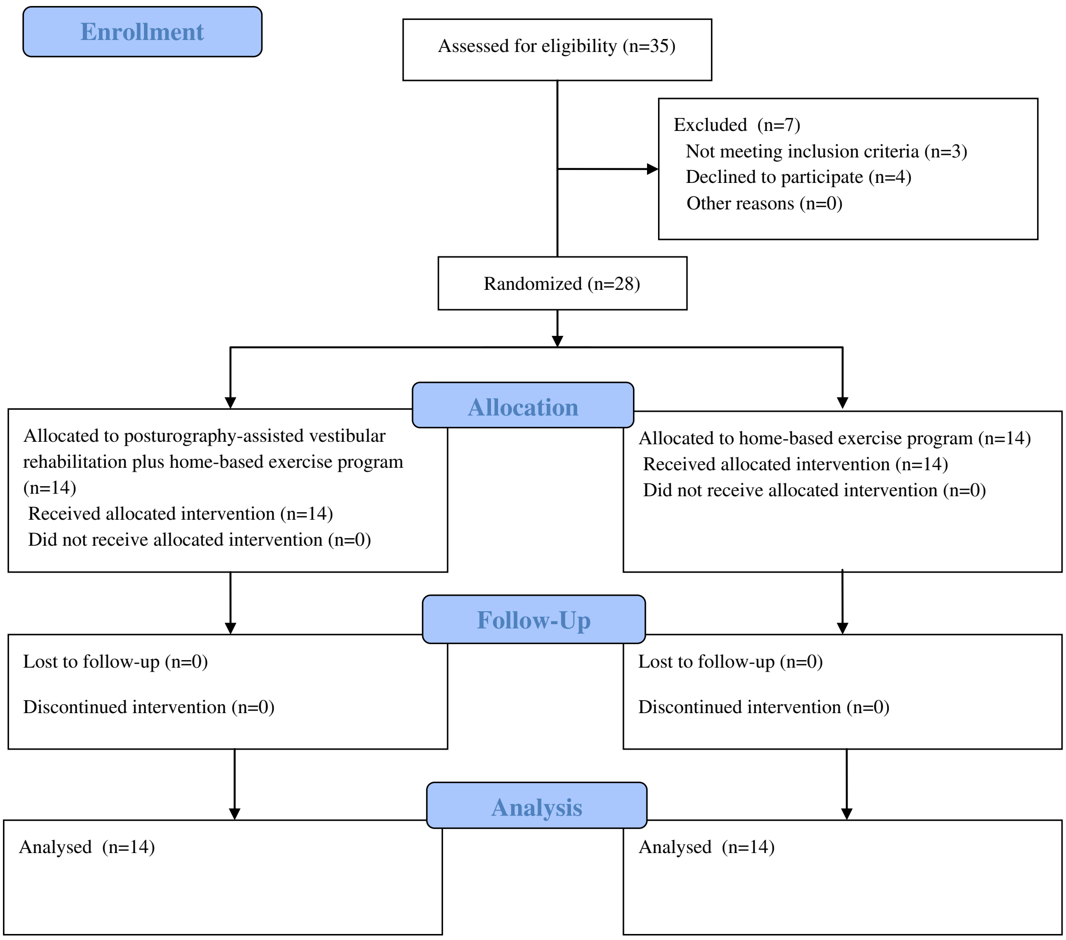

Fig. 6 Participant flow diagram, according to Consolidated Standards of Reporting Trials 2010

preliminary mCTSIB results. There were also no significant differences between the two groups' mean baseline motor test (LOS) results (Mann–Whitney test, RT p=0.50, MVL p=0.78, EPE p=0.40, MXE p=0.51, DC p=0.64) (Table 2).

Final (T1) DHI and computerized posturographic results: within-group comparisons

In group A, the median DHI scores after the 6-week rehabilitation program were F=8 (mean

Table 1 Preliminary posturographic results (T0): mCTSIB

Variables	Group A (Mean ± SD)	Group B (Mean ± SD)	p^{a} Group A vs B
mCTSIB (deg/s)			
Eyes open/firm surface	0.3±0.3	0.2±0.3	NS
Eyes closed/firm surface	0.5±0.5	0.4±0.5	NS
Eyes open/foam surface	1.1±0.6	0.9±0.6	NS
Eyes closed/foam surface	3.1±1.3	2.4±0.6	NS

mCTSIB modified Clinical Test of Sensory Organization and Balance, *NS* not significant

[a] Mann–Whitney test

Table 2 Preliminary posturographic results (T0): LOS

Variables	Group A (Mean±SD)				Group B (Mean±SD)				p^a Group A vs B			
LOS	*A*	*P*	*R*	*L*	*A*	*P*	*R*	*L*	*A*	*P*	*R*	*L*
RT (s)	1.3±0.5	1.2±0.3	1.1±0.2	1.3±0.6	1.4±0.4	1.3±0.6	1.5±0.6	1.3±0.4	NS	NS	NS	NS
MVL (deg/s)	2.1±1.3	1.6±0.6	2.7±1.1	2.7±1.1	2.2±0.9	2.1±0.9	2.7±2.0	2.9±1.7	NS	NS	NS	NS
EPE (%LOS)	56.7±9.2	43.4±19.9	67.4±8.5	69.2±11.0	61.6±23.7	53.8±13.6	66.1±25.0	73.6±19.4	NS	NS	NS	NS
MXE (%LOS)	75.0±15.0	63.8±25.1	88.3±13.6	86.9±11.0	74.3±22.9	72.8±16.2	83.6±25.6	82.6±20.3	NS	NS	NS	NS
DC (%LOS)	78.4±12.9	72.4±13.5	81.6±14.6	82.2±10.5	83.3±11.9	79.2±15.5	84.1±8.5	82.4±6.4	NS	NS	NS	NS

LOS limits of stability, *RT* reaction time, *MVL* movement velocity, *EPE* endpoint excursion, *MXE* maximum excursion, *DC* directional control, *A* anterior, *L* left, *NS* not significant, *P* posterior, *R* right

[a] Mann–Whitney test

9.4±7.2), E=5 (mean 8.4±10.0), P=9 (mean 8.9±7.7), and total=25 (mean 26.7±22.7). These patients' mean DHI scores were significantly lower after the treatment for the F domain (Wilcoxon rank sum test, p=0.0016), the E domain (Wilcoxon rank sum test, p=0.01), and the total score (Wilcoxon rank sum test, p=0.001), but not for the P domain (Wilcoxon rank sum test, p=0.60). In group B, only the score in the E domain improved significantly (Wilcoxon rank sum test, p=0.038) after 6 weeks of home-based rehabilitation, when this group's median DHI scores were F=12 (mean 10.0±8.3), E=6 (mean 8.7±7.5), P=6 (mean 6.7±3.6), and total=27 (mean 25.4±17.2). The statistical analyses on the sensory test (mCTSIB) and motor test (LOS) results obtained in groups A and B are shown in Tables 3 and 4, respectively.

Final (T1) DHI and computerized posturographic results: between-group comparisons

Statistical analysis on the post-treatment DHI scores ruled out any significant differences between groups A and B for the various domains (F, E, and P) or total scores (Mann–Whitney test, p=0.90, p=0.62, p=0.61, and p=0.90, respectively). The analyses on the sensory test (mCTSIB) and motor test (LOS) results obtained in groups A and B at T1 are shown in Tables 5 and 6, respectively.

Discussion

Balance is a generic term describing both postural steadiness (static balance) and postural stability (dynamic

Table 3 Comparison between posturographic results at T0 and T1: mCTSIB

Variables	Group A T0 (mean ± SD)	Group A T1 (mean ± SD)	p^a Group A (T0 vs T1)	Group B T0 (mean ± SD)	Group B T1 (mean ± SD)	p^a Group B (T0 vs T1)
mCTSIB (deg/s)						
Eyes open/firm surface	0.3±0.3	0.2±0.2	NS	0.2±0.3	0.2±0.2	NS
Eyes closed/firm surface	0.5±0.5	0.3±0.3	NS	0.4±0.5	0.3±0.3	NS
Eyes open/foam surface	1.1±0.6	1.0±0.6	NS	0.9±0.6	0.9±0.6	NS
Eyes closed/foam surface	3.1±1.3	2.9±1.1	NS	2.4±0.6	2.2±0.7	NS

mCTSIB modified Clinical Test of Sensory Organization and Balance, *NS* not significant

[a] Wilcoxon rank sum test

Table 4 Comparison between posturographic results at T0 and T1: LOS

Variables	Group A				Group A				p[a]			
	T0 (mean ± SD)				T1 (mean ± SD)				Group A (T0 vs T1)			
LOS	*A*	*P*	*R*	*L*	*A*	*P*	*R*	*L*	*A*	*P*	*R*	*L*
RT (s)	1.3±0.5	1.2±0.3	1.1±0.2	1.3±0.6	1.3±0.3	0.9±0.3	1.1±0.3	1.1±0.3	NS	0.01	NS	0.04
MVL (deg/s)	2.1±1.3	1.6±0.6	2.7±1.1	2.7±1.1	2.6±1.0	2.2±0.5	3.3±1.3	3.3±1.1	0.02	0.007	0.01	NS
EPE (%LOS)	56.7±9.2	43.4±19.9	67.4±8.5	69.2±11.0	62.8±9.2	61.6±18.4	72.6±7.3	71.4±15.0	0.03	0.01	NS	NS
MXE (%LOS)	75.0±15.0	63.8±25.1	88.3±13.6	86.9±11.0	75.3±17.0	83.1±10.8	98.6±14.4	89.7±13.7	NS	0.01	NS	NS
DC (%LOS)	78.4±12.9	72.4±13.5	81.6±14.6	82.2±10.5	81.1±14.1	79.6±11.4	90.6±13.7	87.0±10.6	NS	0.02	NS	NS

Variables	Group B				Group B				p[a]			
	T0 (mean ± SD)				T1 (mean ± SD)				Group B (T0 vs T1)			
LOS	*A*	*P*	*R*	*L*	*A*	*P*	*R*	*L*	*A*	*P*	*R*	*L*
RT (s)	1.4±0.4	1.3±0.6	1.5±0.6	1.3±0.4	1.5±0.5	1.1±0.3	1.6±0.4	1.3±0.2	NS	NS	NS	NS
MVL (deg/s)	2.2±0.9	2.1±0.9	2.7±2.0	2.9±1.7	2.3±0.7	2.0±0.3	2.5±0.7	2.8±1.2	NS	NS	NS	NS
EPE (%LOS)	61.6±23.7	53.8±13.6	66.1±25.0	73.6±19.4	66.7±19.9	55.7±13.6	65.4±15.7	69.1±16.7	0.037	NS	NS	NS
MXE (%LOS)	74.3±22.9	72.8±16.2	83.6±25.6	82.6±20.3	76.4±18.0	76.1±20.1	85.0±18.2	78.6±20.4	NS	NS	NS	NS
DC (%LOS)	83.3±11.9	79.2±15.5	84.1±8.5	82.4±6.4	86.1±4.6	77.1±20.3	83.3±9.7	84.6±7.0	NS	NS	NS	0.001

LOS limits of stability, *RT* reaction time, *MVL* movement velocity, *EPE* endpoint excursion, *MXE* maximum excursion, *DC* directional control, *A* anterior, *L* left, *NS* not significant, *P* posterior, *R* right

[a] Wilcoxon rank sum test

Table 5 Posturographic results after 6 weeks (T1) in groups A and B: mCTSIB

Variables	Group A (Mean ± SD)	Group B (Mean ± SD)	p^a Group A vs B
mCTSIB (deg/s)			
Eyes open/firm surface	0.2±0.2	0.2±0.2	NS
Eyes closed/firm surface	0.3±0.3	0.3±0.3	NS
Eyes open/foam surface	1.0±0.6	0.9±0.6	NS
Eyes closed/foam surface	2.9±1.1	2.2±0.7	NS

mCTSIB modified Clinical Test of Sensory Organization and Balance, *NS* not significant

[a] Mann–Whitney test

balance) (Chaudhry et al. 2011). It is a complex biological function that relies on sensory inputs from the visual, proprioceptive and vestibular systems, which converge towards the vestibular nuclei, where they are integrated and result in the induction of oculomotor and postural stabilization synergies. Computerized posturography can objectively measure changes in vestibular impairments and has been widely used since the mid-1980s to test balance in the clinical setting. An advantage of this approach lies in that it considers the interaction of the three above-mentioned sensory systems in maintaining postural stability (Clarke 2010). The information available on the role of posturography in vestibular rehabilitation is still rather limited, however. While posturography-assisted rehabilitation using visual feedback seems to reduce sway during stance and to improve postural control (Cakrt et al. 2010), little is known about its usefulness in rehabilitation programs, particularly for elderly patients with central vestibular dysfunctions.

The use of vestibular exercises to treat patients with chronic peripheral vestibular lesions has become relatively popular. The purpose of rehabilitation in these patients is simply to facilitate or accelerate the natural process of spontaneous compensation. Patients with central vestibular dysfunctions pose a greater challenge, however, and the results of vestibular rehabilitation are often less rapidly evident and favorable due to the involvement of the centers responsible for adaptation and compensation (Furman and Whitney 2000; Suarez et al. 2003). These considerations apply particularly to the elderly whose physiological cerebral aging phenomena are bound to exacerbate the difficulty of their rehabilitation, though old age per se is not a contraindication (Guidetti 1997). Our prospective, randomized preliminary

Table 6 Posturographic results after 6 weeks (T1) in groups A and B: LOS

Variables	Group A (Mean±SD)				Group B (Mean±SD)				p^a Group A vs B			
LOS	*A*	*P*	*R*	*L*	*A*	*P*	*R*	*L*	*A*	*P*	*R*	*L*
RT (s)	1.3±0.3	0.9±0.3	1.1±0.3	1.1±0.3	1.5±0.5	1.1±0.3	1.6±0.4	1.3±0.2	NS	0.02	0.007	NS
MVL (deg/s)	2.6±1.0	2.2±0.5	3.3±1.3	3.3±1.1	2.3±0.7	2.0±0.3	2.5±0.7	2.8±1.2	NS	NS	0.03	NS
EPE (%LOS)	62.8±9.2	61.6±18.4	72.6±7.3	71.4±15.0	66.7±19.9	55.7±13.6	65.4±15.7	69.1±16.7	NS	NS	NS	NS
MXE (%LOS)	75.3±17.0	83.1±10.8	98.6±14.4	89.7±13.7	76.4±18.0	76.1±20.1	85.0±18.2	78.6±20.4	NS	NS	NS	NS
DC (%LOS)	81.1±14.1	79.6±11.4	90.6±13.7	87.0±10.6	86.1±4.6	77.1±20.3	83.3±9.7	84.6±7.0	NS	NS	NS	NS

LOS limits of stability, *RT* reaction time, *MVL* movement velocity, *EPE* endpoint excursion, *MXE* maximum excursion, *DC* directional control, *A* anterior, *L* left, *NS* not significant, *P* posterior, *R* right

[a] Mann–Whitney test

investigation on elderly patients with problems of balance due to central vestibular dysfunction was conducted to compare the effectiveness of a posturography-assisted vestibular rehabilitation protocol combined with a home-based exercise program (group A) as opposed to the same home-based exercise program alone (group B). As part of their posturography-assisted vestibular rehabilitation protocol, patients in group A received immediate visual feedback on their postural forces in the form of flowing movements of the COG marker on the computer screen. They moved the COG marker by leaning their body in a given direction and the level of difficulty in maintaining a certain posture naturally increased with the participant's leaning angle (Hirvonen et al. 1997). It is very important to ensure that patients understand how to move and control the cursor before starting any test or rehabilitation exercises, so the physiotherapist had a significant part to play in the posturography-assisted rehabilitation process for group A, helping patients to complete the procedures properly. In the early stages of the rehabilitation program, the physiotherapist frequently had to convince patients to repeat each procedure more than once, supporting some of the more emotional patients and giving them confidence. Routinely identifying their errors in technique and suggesting corrective strategies helped patients to improve their bodily and spatial perception (Marioni et al. 2012). For instance, it was often necessary during the posturography-assisted vestibular rehabilitation sessions to remind patients how important it was to pay attention to the pressure exerted by the soles of their feet, explaining how it increased or decreased in the various areas of the sole of the foot with the displacement of their center of gravity.

The Dizziness Handicap Inventory is a disease-specific, health-related quality of life questionnaire that measures patients' perception of their dizziness-related handicap (Goto et al. 2011; Eleftheriadou et al. 2012). The primary goal of our preliminary study was to use the DHI to establish whether our patients' quality of life improved after the two different rehabilitation protocols. A highly significant reduction in the mean DHI scores was recorded in group A after the treatment, for the functional and emotional domains and for the total score (but not for the physical domain). In group B, only the emotional domain improved to a significant degree after the home-based rehabilitation alone. Although our findings have some limitations (due mostly to the limited number of patients enrolled), the better results obtained in group A than in group B can reasonably be attributed to the following: (1) the different rehabilitation protocol, which included posturography-assisted rehabilitation for group A, and (2) the opportunity afforded by the weekly supervised posturography-assisted rehabilitation sessions for patients in group A to discuss their problems and correct any inappropriate application of the home-based rehabilitation exercises. In particular, the combined rehabilitation scheme applied for group A seemed to enable patients to take an active part in their own treatment, and the positive results they obtained encouraged them to cope better with their balance disorder. Reviewing available literature, we found that Brown et al. (2006) retrospectively considered 48 patients with central vestibular disorders who had undergone a custom-designed physical therapy program. Patients completed the Activities-Specific Balance Confidence Scale, DHI, Dynamic Gate Index (DGI), Timed Up and Go (TUG) test, and Five Times Sit-to-Stand (FTSTS) test. Although the diagnostic modalities were not definitely reported in the paper, the sub-cohort of patients that seems more consistent with our series is the "central vestibulopathy" group (13 cases, mean age 65.5± 16.0 years). In the central vestibulopathy group, a significant post-rehabilitation improvement was found in DHI, DGI, and TUG test. More recently, Moreira Bittar and de Giacomo (2011) prospectively evaluated eight patients (mean age 67.75 years) with central imbalance who were treated with 18 sessions of tongue electrotactile stimulation; 75 % of the patients reported being more stable, but there was no improvement in the balance control at computed dynamic posturography. As found also in our study comparing DHI vs computerized posturography results, it was widely reported that patients with central vestibular dysfunctions respond to rehabilitation mostly with improvements in subjective measures of the effect of dizziness and disequilibrium on daily life (Trato and Johnson 2010).

The term "static" standing balance has been used to describe how well individuals can keep still (minimizing any displacement of their COG). Judging from our preliminary posturographic results, the modified Clinical Test of Sensory Organization and Balance ruled out any improvement in COG control after the rehabilitation program in either of our study groups in any of the

following conditions: eyes open/firm surface, eyes closed/firm surface, eyes open/foam surface, and eyes closed/foam surface. The term “dynamic” standing balance refers to how well individuals can lean or shift their weight over a stable base of support in a controlled manner. The LOS test is a dynamic standing balance test that measures intentional COG control. The speed, direction, and distance of COG movements must all be well controlled, and the LOS test measures all three. Patients were asked to “move as quickly and accurately as possible” to each of the targets. After completing the rehabilitation program (T1), group A patients showed a significant improvement in some of the parameters considered in the motor tests (LOS), i.e., a rapid reaction time is naturally desirable, and the mean RT in group A after rehabilitation was significantly shorter in the posterior and left directions (p=0.01 and p=0.04, respectively); the MVL and EPE values also improved significantly in group A for most of the directions considered, whereas only a very few of the motor test scores showed any improvement in group B (EPE anterior direction, DC left direction).

Literature to support the use of vestibular rehabilitation in the treatment of central vestibular disorders is scanty (Trato and Johnson 2010). Furthermore, it is difficult to categorize all patients with central vestibular dysfunction as a single group; individual central vestibular diagnostic groups might respond differently to rehabilitative intervention (Brown et al. 2006). Our preliminary outcomes in elderly patients with an impaired central vestibular function support the hypothesis that better results are achievable with a 6-week customized program of vestibular rehabilitation combining posturography-assisted vestibular rehabilitation with home-based exercises than with home-based exercises alone. Based on these findings, the expense of training a physiotherapist to manage elderly patients with a central vestibular dysfunction is reasonably justifiable. The best approach to vestibular rehabilitation would be to form a qualified professional team including at least one otolaryngologist and a specifically trained physiotherapist. When dealing with elderly patients whose independence inevitably tends to decline, it is best to involve the family, making sure they are aware of the patient’s balance-related limitations and ensuring their support and contribution in the home-based rehabilitation protocols. The main limitation of the present study is necessarily the small numbers of the population considered that is a consequence of our inclusion criteria designed to obtain a very homogeneous cohort from vestibulogical viewpoint. A confirmatory experiment based on the present study protocol (involving at least 47 cases in group A and 47 cases in group B) has been planned. Furthermore, the University of Padova’s Otolaryngology Section is currently conducting a new, prospective, randomized study on a larger sample of elderly patients with problems of balance due to central vestibular pathway disorders to ascertain (1) the effectiveness of a rehabilitation protocol relying on posturography-assisted vestibular rehabilitation alone and (2) the relationship between outcomes and the duration of rehabilitation programs.

Acknowledgments This study was supported in part by grant no. 60A07-3774/11 (G. Marioni) from the University of Padova. The authors thank Frances Coburn for correcting the English version of the paper and Rosa Marchioro and Sergio Tomasin for their photographic contribution.

Appendix

The preferred posturography-assisted vestibular rehabilitation program involved the following sequence of shifts in body weight: (1) center to anterior to center (LOS ranging from 50 to 70 %, pacing from 5 to 7 s, duration 2 min); (2) center to right lateral to center (LOS ranging from 50 to 70 %, pacing from 5 to 7 s, duration 2 min); (3) center to posterior to center (LOS ranging from 50 to 70 %, pacing from 5 to 7 s, duration 2 min); (4) center to left lateral to center (LOS ranging from 50 to 70 %, pacing from 5 to 7 s, duration 2 min); (5) anterior to posterior to anterior (LOS ranging from 50 to 70 %, pacing from 5 to 7 s, duration 2 min); (6) left lateral to right lateral to left lateral (LOS ranging from 50 to 70 %, pacing from 5 to 7 s, duration 2 min); (7) right anterior to left posterior to right anterior (LOS ranging from 50 to 70 %, pacing from 5 to 7 s, duration 2 min); (8) left anterior to right posterior to left anterior (LOS ranging from 50 to 70 %, from 5 to 7 s, duration 2 min); (9) circling to right or clockwise (LOS ranging from 50 to 70 %, pacing from 5 to 7 s, duration 2 min); and (10) circling to left or counterclockwise (LOS ranging from 50 to 70 %, pacing from 5 to 7 s, duration 2 min).

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