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Faculteit Revalidatiewetenschappen

master in de revalidatiewetenschappen en de kinesitherapie

Masterthesis

Impact of Benign Paroxysmal positional vertigo (BPPV) and treatment effect of repositioning maneuvers on balance, frailty, limitations due to dizziness, fear of falling and depression

Stien De Bondt
Audrey Prud'homme

Scriptie ingediend tot het behalen van de graad van master in de revalidatiewetenschappen en de kinesitherapie, afstudeerrichting revalidatiewetenschappen en kinesitherapie bij musculoskeletale aandoeningen

PROMOTOR :

Prof. dr. Joke SPILDOOREN

BEGELEIDER :

Mevrouw Sara PAUWELS

2023
2024

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Setting

This study investigates the impact of benign paroxysmal positional vertigo (BPPV) and repositioning maneuvers as therapeutic treatment on various aspects including balance, frailty, impairments due to vertigo, fear of falling and depression among older adults. It holds significant scientific and practical implications across several domains. Firstly, it contributes to health care by shedding light on a prevalent condition among older adults, potentially enhancing their quality of life and alleviating healthcare burdens by reducing recurrent medical consultations and hospitalizations. Secondly, it aids in the formulation of efficacious interventions aimed at fall prevention, thereby preserving mobility and independence in older adults. Moreover, by potentially limiting healthcare expenditures, this research bears relevance to public health initiatives. Lastely, it advances our scientific understanding of the complex interaction between vertigo, balance impairments, frailty, and mental well-being in older adults, paving the way for future advancements in treatment strategies and interventions.

This master's thesis is situated within an ongoing research project at Hasselt University, within the REVAL research group. It is part of the doctoral study of Pauwels Sara entitled "Benign Paroxysmal Positioning vertigo in older adults: treatment efficacy and the impact on balance, inactivity and frailty". This study is registered under the B-number B3712021000013.

The study is conducted in cooperation with Ziekenhuis Oost Limburg (ZOL), at this location the participants were received and tests were performed. Various equipment and measuring devices available on site were used. The participants for the study were partly recruited from the ZOL, from the network of 'Senioren Universiteit Vlaanderen', 'OKRA Limburg', 'Happy Aging Bioville' and from the network of researchers and patients itself.

This master thesis is drafted by De Bondt Stien and Prud'homme Audrey, together in consultation with co-supervisor Pauwels Sara the research question was drafted. The remaining parts of the master thesis were carried out in collaboration, both offered contributions to all parts of the research.

Abstract

Background: Benign paroxysmal positional vertigo (BPPV) is a common vestibular disorder in older adults and is treated with repositioning maneuvers (PRM). It has a significant impact on balance, frailty, dizziness, fear of falling and depression, therefore we examined the impact of BPPV and treatment effects.

Objectives: This study examines the influence of BPPV and PRM as treatment on balance, frailty, dizziness limitations, fear of falling and depression between follow-up moments (pre-post1-post2).

Methods: This longitudinal experimental study was conducted in older adults (≥65 years). 25 people with BPPV and 22 people without BPPV completed questionnaires (DHI, FES-I, GDS-15 and MOCA) and tests (Mini-BESTest, 10MWT and Fried criteria).

Results: Findings indicate higher medication use and lower cognitive scores in BPPV patients. They also showed higher scores on the dizziness handicap inventory (DHI) ($p = <0.001$), but these decreased significantly after PRM (after post1 and post2, $p = <0.001$). Initial balance scores were lower in BPPV patients ($p = 0.005$), but they improved with treatment (after post1 $p = 0.010$; after post2 $p = 0.004$). BPPV patients also exhibited slower walking speed (after post2 $p = <0.001$) and increased frailty compared to the control group ($p = <0.001$).

Conclusion: BPPV has an impact on an individual's daily functioning, it can be reduced by performing PRM. This study found that after one month there was a significant increase on DHI, FES-I and Mini-BESTest and after three months on DHI, FES-I, Mini-BESTest and 10MWT.

Keywords: BPPV, older adults, PRM, treatment efficacy, balance, frailty, dizziness limitations, fear of falling, depression

Introduction

Benign Positional Paroxysmal Vertigo (BPPV) is the leading cause of dizziness in older adults, most frequent in women (Oghalai, Manolidis, Barth, Stewart, & Jenkins, 2000). Usually it is idiopathic, but other causes are possible (Caldas, Ganança, Ganança, Ganança, & Caovilla, 2009). The prevalence is 10.7-64/100.000 with a lifetime prevalence of 2.4% (Bhattacharyya et al., 2017). Diagnosis is based on an anamnesis and a positive Dix-Hallpike-, Supine Roll- or Side Lying-maneuver (Lança et al., 2013). The prognosis is favorable with resolution within days or weeks in 25-50% of the cases, but recurrence is common (Heidi B. Schwarz MD, 2023) (Niemensivu, 2017).

The vestibular system, responsible for detecting head motion and position (You, Instrum, & Parnes, 2019), can lead to BPPV symptoms when there is abnormal signal transduction through the semicircular canals. This causes an illusory sense of motion (You et al., 2019), which can lead to dizziness and disrupted balance. This disruption may lead to an increased fear of falling and limitations in their activities of daily living, hindering their social interactions and causing feelings of depression. While BPPV can occur in any of the three semicircular canals, the posterior canal variant is the most common (80-90%) due to its heightened sensitivity to gravity (You et al., 2019).

Pathogenesis, diagnosis, and treatment of BPPV are similar across age groups (Balatsouras, Koukoutsis, Fassolis, Moukos, & Apris, 2018). However, BPPV is more common in older adults, tend to respond less effectively to treatment and have a higher recurrence rate. Specific problems in older adults include relationship to falls, challenges in obtaining accurate anamnesis, and difficulties in performing diagnostic and therapeutic maneuvers safely (Balatsouras et al., 2018). The study by Balatsouras et al. (2018) shows that untreated or undiagnosed BPPV in older adults can lead to increased burden on caregivers and societal costs, including decreased family productivity and an elevated risk of nursing home placement.

BPPV treatment involves repositioning maneuvers like the Epley and Semont maneuvers, primarily used for posterior canal BPPV, which are proven safe and effective in research studies, providing long-term resolution. The Lempert and Guffoni maneuvers

can be utilized for horizontal canal BPPV. Involvement of a physiotherapist is crucial for ensuring proper execution and successful treatment (Power, Murray, & Szmulewicz, 2020) (Niemensivu, 2017) (Heidi B. Schwarz MD, 2023).

Frailty is characterized by a decline in multiple body systems, leading to functional limitations and increasing risk of adverse health outcomes (Cesari, 2019). This includes higher hospitalization rates, increased falls, and elevated mortality. Risk factors include polypharmacy, physical inactivity, socioeconomic factors, malnutrition, cognitive impairment, and comorbidities. Diagnosis is made using Fried's Phenotype, assessing unintentional weight loss, low energy, slowness, weakness, and low physical activity. Three out of five criteria indicate "frailty", one or two indicate "prefrailty" and none indicate "robustness" (Heidi B. Schwarz MD, 2023) (Zheng, Lv, Rong, Sun, & Chen, 2023).

Postural control, crucial for daily activities, involves maintaining the center of gravity above the base of support. It integrates input from the vestibular, somatosensory, motor, and visual systems (Horak, Wrisley, & Frank, 2009). The Mini-BESTest evaluates various aspects of postural control based on Horak's framework which includes biomechanical constraints, stability limits, verticality, anticipatory postural adjustments, postural responses, sensory orientation, and gait stability. Vestibular symptoms associated with BPPV can disrupt multiple aspects of postural control (Horak et al., 2009). This study aims to assess the impact of BPPV and repositioning maneuvers on balance, frailty, limitations due to dizziness, fear of falling and depression in older adults. Our hypothesis is that individuals with BPPV demonstrate poorer balance, increased frailty, more dizziness-related limitations, heightened fear of falling, and elevated depression scores compared to the control group. We expect these outcomes due to the incorrect perception of balance causing dizziness, leading to activity limitations and fear of falling. We anticipate improvement after treatment wit PRM in all patients with BPPV. However in older adults diagnosing is more complicated, more PRM will be necessary and a decreased neck mobility and cooperation is possible. There is also an increased risk of recurrence in this population (Laurent et al., 2022).

Methods

Participants

This study was approved by the ethical committee of Ziekenhuis Oost Limburg (ZOL) and University of Hasselt on the 31 of May 2021. The study was registered under B-number B3712021000013.

In this longitudinal experimental study, a control- and intervention-group was used. For the intervention group a representative sample of community-dwelling older adults aged ≥65 years, who received a diagnosis of BPPV at the vestibular department of Ziekenhuis Oost-Limburg (ZOL) Genk was recruited. The control group, without BPPV, was matched for age, gender, and height, was recruited through the network of 'Senioren Universiteit Vlaanderen', 'OKRA Limburg', 'Happy Aging Bioville' and the network of researchers and patients themselves.

The **inclusion criteria** for both groups were individuals 1) aged 65 years or older, 2) with the ability to independently maintain a standing position for at least 30 seconds and 3) with the ability to walk a minimum of 10 meters with or without a walking aid. A specific inclusion criteria for the intervention group was: individuals with a confirmed diagnosis of posterior semicircular canal BPPV or lateral-semicircular canal BPPV (geotropic or ageotropic).

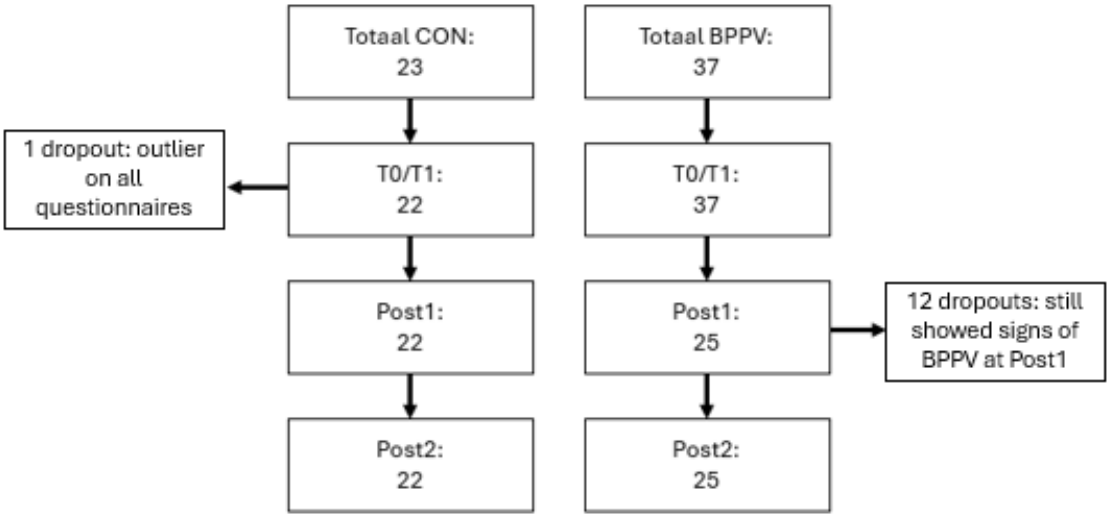
Exclusion criteria were 1) the inability to comprehend and adhere to simple instructions due to conditions such as severe dementia, hearing loss, or visual impairment, 2) individuals residing temporarily or permanently in a residential care center, psychiatric facility, home for the disabled, or rehabilitation center, 3) individuals with contra-indications for diagnostic maneuvers, including severe limitations in cervical spine mobility, 4) Individuals in the rehabilitation phase after an orthopedic or cardiovascular incident and 5) individuals who still have or again had a confirmed diagnosis of BPPV at follow up 6) individuals who had a complete resolution of all BPPV symptoms before all measures were performed prior to the repositioning maneuver.

Procedure

After the selection procedure, a total of 47 participants remained, of these, 23 were in the control group and 37 in the intervention (BPPV) group (Figure 1). Throughout the study, one person dropped out of the control group because it was an outlier for all questionnaires, this left them with 22. In the intervention (BPPV) group, 12 participants dropped out during the study because they had a confirmed diagnosis of BPPV at measure moment 2. Both groups were followed up for three months. At T0 the patients were checked for BPPV and diagnosed. They also received questionnaires to complete at home. At T1 the remaining tests were completed. T0 and T1 were seen as one measure moment (pre) for the statistics. Measure moment 2 (post1) took place approximately one month after T1. Measure moment 3 (post2) took place approximately three months after T1. More information on which test was completed when can be found in Figure 2. Primary outcome measures were the Mini-BESTest, FES-I, DHI, GDS-15, Fried criteria, 10MWT. A secondary outcome measure was the MOCA. Subject characteristics (age, gender, living situation, medication use, comorbidities, BPPV symptoms, walking aid and fall history) were used to match both groups.

Figure 1

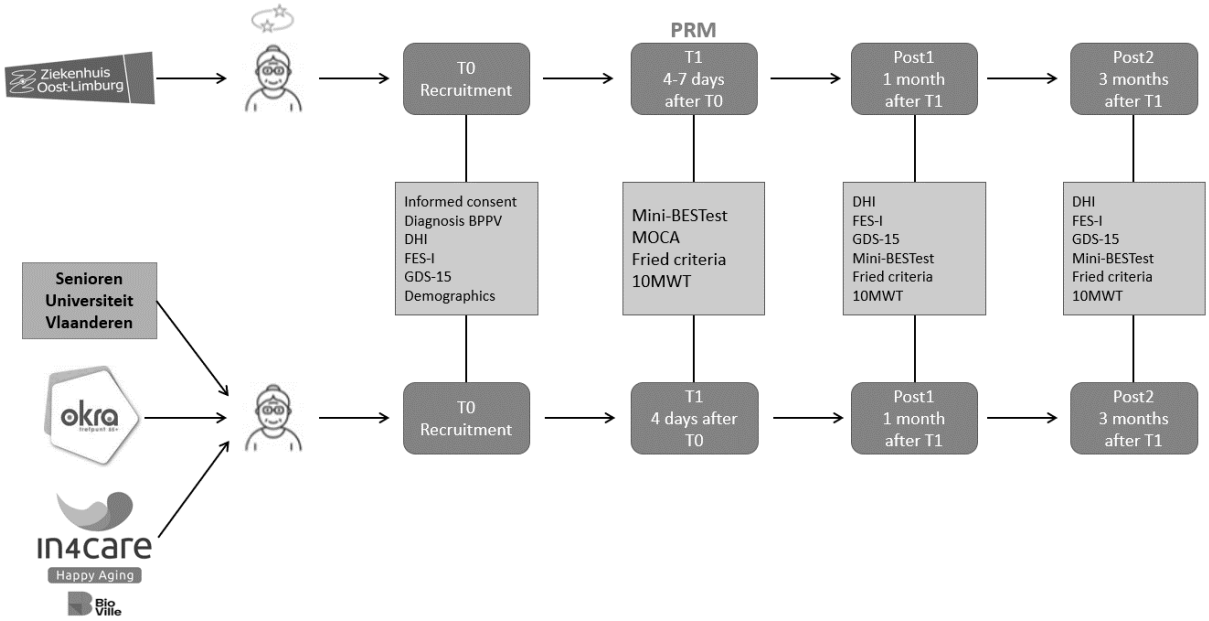
Number of Participants During the Study



Note. Flowchart illustrates the number of participants at different measure moments during the study. CON = Control Group, BPPV = Benign Paroxysmal Positional Vertigo, T0/T1 = Measure Moment 1, Post1 = Measure Moment 2, Post2 = Measure Moment 3

Figure 2

Course of the study



Note. PRM = Particle Repositioning Maneuvers, BPPV = Benign Paroxysmal positional vertigo, DHI = Dizziness Handicap Inventory, FES-I = Falls Efficacy Scale International, GDS-15 = Geriatric Depression Scale 15, Mini-BESTest = Mini Balance Evaluation Systems Test, MOCA = Montreal Cognitive Assessment, 10MWT = 10 Meter Walk Test, T0 = Measure Moment , T1 = Measure Moment 1, Post1 = Measure Moment 2, Post2 = Measure Moment 3

At T0, the diagnosis of BPPV was performed by Sara Pauwels using videonystagmography (VNG). After informed consent, patients were given questionnaires to complete at home. These questionnaires include the Dizziness Handicap Inventory (DHI), the Falls Efficacy Scale (FES-I) and the Geriatric Depression Scale (GDS-15) to assess the impact of dizziness on patients' daily lives, fear of falling and depressive feelings, respectively at post1 and post2 these questionnaires were completed in the hospital. General questionnaires were also included to capture participants' characteristics.

Subjective characteristics questionnaires, including age, height, gender, weight, sleep paterns, medication use, cognition, walking aide use and comorbid conditions were assessed at time point T0.

For the diagnosis of BPPV, the Dix-Hallpike maneuver and supine roll test were used. When the Dix-hallpike maneuver was positive, posterior semicircular canal BPPV was diagnosed. The maneuver was performed according to the following steps: 1) patient in a sitting position with head turned 45°, 2) supine position with head straight rotated, 3) return to sitting position (Karawani et al., 2018). The patient showed a torsional up beating nystagmus towards the affected (lower) ear when being brought into the supine position. When returning to the seated position a less intense torsional down beating nystagmus must have been observed to make the diagnosis.

When the supine roll test was positive, lateral-semicircular canal BPPV was diagnosed. A difference was made between the geotropic and the ageotropic variant. For both forms the supine roll test was used. The test was performed according to the following steps: 1) patient in supine position with head in 30° flexion, 2) rotate head to one side and hold, 3) rotate head to the other side and hold (Cohen, 2019). The geotropic variant was diagnosed when the supine roll test resulted in a pronounced horizontal nystagmus towards the lower ear (geotrope). Rotation of the head to the opposite side should have provoked a less intense nystagmus toward the opposite ear, still geotropic. The affected ear was identified by the direction of the most intense nystagmus. The ageotropic variant was diagnosed when the supine roll test resulted in a pronounced horizontal nystagmus toward the upper ear. Head rotation to the other side should have provoked a similar horizontal nystagmus towards the upper ear.

The assessment of the impact of dizziness on daily life was conducted by evaluating the **Dizziness Handicap Inventory (DHI)** (Jacobson & Newman, 1990) (appendix 3), with a required time of about 7 minutes. The test can be further divided into three subscales: functional, physical and emotional impact on disability. Research showed that this measurement tool is reliable and valid. This assessment was reconducted at multiple time points, specifically at T0, post1 and post2. A score between 16 and 34 indicated mild handicap, a score between 36 and 52 indicated moderate handicap, and a score higher than 54 indicated severe handicap (Verdecchia et al., 2020).

Assessment for fear of falling was conducted using the **Falls Efficacy Scale (FES-I)** (Tinetti, Richman, & Powell, 1990) (appendix 2) with an estimated time required of 5 minutes. Fear of falling was assessed at T0, post1 and post2. A score between 16 and 19 indicates that individuals are little concerned about falling, a score between 20 and 27 indicates that individuals were moderately concerned about falling, and a score between 28 and 64 indicates that individuals are very concerned about falling (Yardley et al., 2005) (Kempen et al., 2007).

Participants' depressive symptoms were assessed using the **Geriatric Depression Scale 15 (GDS-15)** (Yesavage et al., 1982) (appendix 5) at T0, post1 and post2. Research indicated the GDS-15 is a reliable and valid measurement tool and has an expected time of approximately 5 minutes. Upon return to the hospital, it was verified that all questions were filled in correctly. The GDS-15 consisted of 15 'yes' or 'no' questions that assessed depressive symptoms and screened for depression in older adults. A total score out of 15 was calculated from all the different items. A score ranging from zero to four was a normal score, a score ranging from five to nine indicated a mild depression and a score of ten out of 15 suggested a moderate to severe depression (Nyunt, Fones, Niti, & Ng, 2009).

Minimum four and maximum seven days after the initial consultation (T0), the patients were assessed and treated by Drs. Sara Pauwels at T1. To investigate the impact of BPPV on balance, the Mini Balance Evaluation Systems test (Mini-BESTest) and the 10 Meter Walk Test (10MWT) were performed. The Montreal Cognitive Assessment (MOCA) screened for cognitive impairment. Frailty was measured by the Fried criteria adjusted by Avila-Funes. Vestibular function was re-evaluated by the diagnostic maneuvers (Dix-Hallpike, side-lying, or supine roll test) for BPPV using video nystagmography. All patients were treated with particle repositioning maneuvers (PRM) for their specific type of BPPV, the treatment was repeated weekly until positioning nystagmus and vertigo disappeared, with a maximum of three treatment sessions. During a treatment session, the presence of BPPV was first reassessed with diagnostic maneuvers. For posterior canal BPPV, the PRM-cycle was repeated twice during one treatment session, if tolerated by the patient. The number of treatment sessions needed for recovery was recorded for each participant.

The Mini Balance Evaluation System Test (F. Franchignoni, Horak, Godi, Nardone, & Giordano, 2010) (appendix 1) was used to assess dynamic balance, the duration of this test was 20 minutes. This test was performed at three different time points: T1, post1 and post2, under supervision of Drs. Sara Pauwels. The evaluation consisted of a series of 14 dynamic balance tasks, which could be divided into four subscales 1) anticipatory postural control (sit to stand, rise to toes, and stand on one leg), 2) reactive postural control (compensatory stepping correction forward, backward, and lateral), 3) sensory orientation (stance with eyes open on a firm surface, stance with eyes closed on a foam surface and incline stance with eyes closed), 4) dynamic gait (change in gait speed, walking with head turns horizontally, walk with pivot turns, step over obstacles and the timed up and go with dual task). These dynamic balance assessments were conducted to provide a comprehensive evaluation of the participant's balance at the specified time points. A score lower than 19 out of 28 indicated an increased fall risk (Di Carlo, Bravini, Vercelli, Massazza, & Ferriero, 2016).

Gait was evaluated during the **10-Meter Walk Test (10MWT)** with APDM sensors (Collen, Wade, & Bradshaw, 1990) at time points T1, post1 and post2 by drs. Sara Pauwels. Research indicated that the 10MWT was a reliable and valid measurement tool (Peters, Fritz, & Krotish, 2013). The participant was asked to walk 10 meters starting at zero meters and walk at a comfortable speed in a straight line to the end of the hallway (± 12 meters). Only the first 10 meters were used to measure the walking speed in meters per second (Collen et al., 1990).

Cognitive function of the participant was assessed using the **Montreal Cognitive Assessment (MOCA)** (Nasreddine et al., 2005)(appendix 4) at time point T1, with Drs. Sara Pauwels overseeing the evaluation, which took approximately 10 minutes. Research showed that the MOCA was a measurement tool with high validity and diagnostic accuracy to determine cognitive impairment in older people. The MOCA consists of 30 items that evaluated different cognitive domains such as, short-term memory, attention, concentration, orientation in time and space. A total score out of 30 is calculated from all the different items. The authors of the test recommended a clinical cut off score of 26 out of 30. A score below 26 indicated a cognitive impairment. Additional details regarding this assessment could be found in the appendix (Bernier et al., 2023).

Frailty was assessed using the **Fried Criteria** (Fried et al., 2001)**, adjusted by Avila-Funes** (Avila-Funes et al., 2008) with an estimated time of approximately 5 minutes. This evaluation was conducted at T1, post1 and post2.

The assessment consisted of the following components:

- Unintentional weight loss: participants were asked if they had unintentionally lost 3 kilograms or more of their body weight. The Body Mass Index (BMI) was calculated because a BMI lower or equal to 21 was also positive.
- Perceived Exhaustion: Participants were assessed for perceived exhaustion using two statements (1) “If I felt everything I did was an effort” and (2) “I could not get going”. Participants were asked to indicate the frequency of experiencing these feelings over the past week, with possible responses categorized as “rarely or none of the time (>1 day)”, “some or little of the time (1-2 days)”, “a moderate amount of the time (3-4 days)”, or “most of the time (5-7 days)”. This component was considered present when participants responded with 'always or most of the time' to at least one of the two questions
- Walking speed: walking speed was determined based on the results of the 10-meter walk test. A slow walking speed was determined by using the lowest quintile of the aged matched population.
- Functional Strength: participants were inquired about their ability to rise from a chair, with responses recorded as “Yes” or “No”.
- Physical Activity: participants were questioned about their regular engagement in physical activities, including gardening, walking, or sports, with possible responses of “Yes” or “No”.

These frailty assessments encompassed a comprehensive evaluation of various factors to determine participants’ frailty status at the specified time points. A participant was categorized as frail when three or more frailty components were present, when there were one or two components present the participant was categorized as prefrail and when there were no frailty components present the participant was categorized as robust (Avila-Funes et al., 2008). These criteria were used to determine frailty because it is known to be a valid and

easily usable screening tool for frailty in older adults. The modified criteria by Avila-Funes were used because they were more practical, more context-specific, and strive for an effective and reliable identification of frailty (Avila-Funes et al., 2008).

Measure moment 2 (post2) took place approximately one month after T1, outcomes related to balance tests, questionnaires, and presence of BPPV were re-evaluated. Measure moment 3 (post2) took place three months after T1. At that moment, the same outcomes were re-evaluated.

Data-analysis

Sample size calculation and statistical analysis

To receive sufficient power for the comparison of BPPV versus controls, a sample size of 21.22 subjects per group was used (power 80.00% and alpha 0.05). For the comparison pre and post, 22.79 subjects were needed per group (power 80.00% and alpha 0.05)(Cohen-Shwartz, Nechemya, & Kalron, 2020). To evaluate normality of the demographics, the Shapiro-Wilk test was performed and to control for variances, the Brown-Forsythe test was performed. To check whether our two groups were equally distributed for demographics, a 2-sample t-test was performed for age, height, and weight. This test was used to compare continuous data of 2 independent groups. One of both groups had < 30 participants. Both were normally distributed and both groups had ≥ 20 participants and there were equal variances. For categorical data (gender, walking aid and sleep pattern) with 1 factor (group), 2 levels (BPPV/CON) and both groups greater than 5 a Chi-square test was performed. For continuous data (medication, MOCA and comorbidities) with 2 independent groups, both < 30, at least 1 not normally distributed and equal variances a Rank-sum test was performed. For continuous data (DHI, Mini-BESTest, GDS-15, FES-I, 10MWT and Frailty) with influence of categorical and continuous variables, a repeated measures ANOVA with a within and a between measurement was performed. When analyzing the data interaction effects (time & group) and main effects for time and group a post hoc Bonferroni analysis was performed to identify significant differences.

Intervention

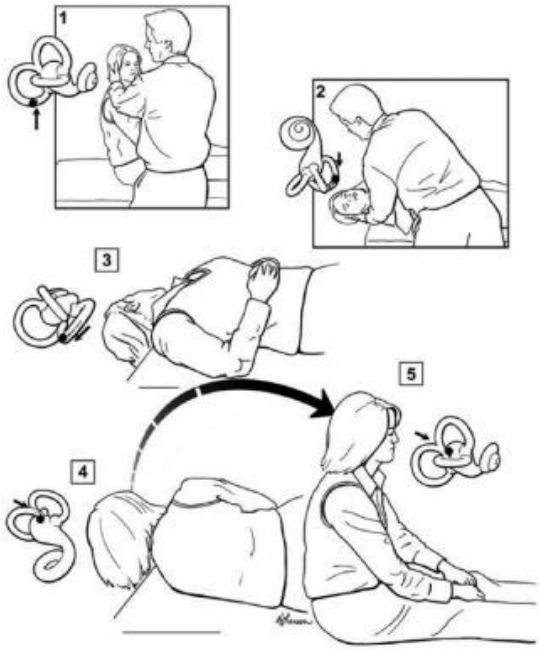
Posterior semicircular canal BPPV

BPPV canalolithiasis of the posterior semicircular canal was treated with the Epley maneuver. Treatment started with the therapist facing the patient and each position must be held until the nystagmus subsides.

1) Start from a position where the patient sits with its head 45° turned to the affected side.
2) Lay the patient down on its back with a neck extension.
3) Keep the neck extension and turn the head 90° degrees to the unaffected side.
4) The patient turns itself fully on the unaffected side with their face towards the table.
5) Bring the patient upright.

Figure 3

Epley Maneuver



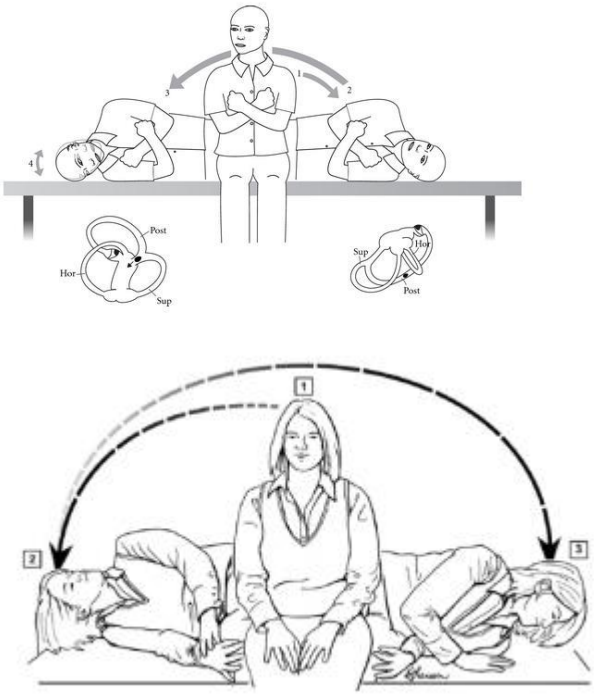
Note. (Bhattacharyya et al., 2017)

BPPV cupulolithiasis of the posterior semicircular canal and patients who were unable to perform the Epley maneuver were treated with the Semont maneuver.

1) Start from a sitting position where the therapist stands in front of the patient.
2) Turn the head 45° to the unaffected side.
3) Lay the patient down on its affected side. The head rests on the table.
4) Hold this position until the dizziness or vertigo disappears.
5) Rotate the patient fast onto the unaffected side.
6) Hold this position until the dizziness or vertigo disappears.

Figure 4

Semont Maneuver



Note. (Bhattacharyya et al., 2017)

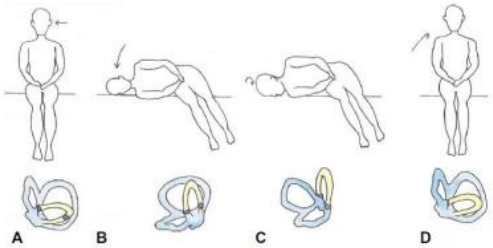
Lateral semicircular canal BPPV: geotropic variant

Geotropic lateral canal BPPV was treated with the Gufoni maneuver.

1) Start from a position where the patient sits with the head straight.
2) Quickly lay the patient down on the unaffected side.
3) Turn the head 45° down and make sure the nose makes contact with the table.
4) Keep this position for 1-2 minutes.
5) Bring the patient upright, with the head facing the unaffected side.
6) Turn the head straight when the patient is upright.

Figure 5

Gufoni Maneuver



Note. (Nuti, Masini, & Mandalà, 2016)

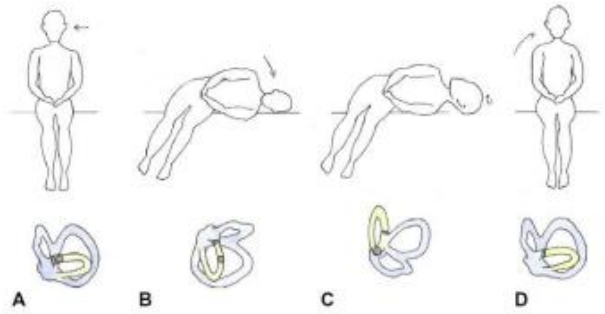
Lateral semicircular canal BPPV: apogeotropic variant

The modified Gufoni's maneuver was the recommended treatment for apogeotropic lateral canal BPPV where the debris is close to the ampulla or on the cupula. During this procedure, the patient starts in a sitting position, the next steps are followed:

1) Move the patient rapidly to the affected side, without moving the head.
2) After 30 seconds, rotate the patient's head 45° upward, directing their nose toward the ceiling.
3) Maintain this head position for 1-2 minutes.
4) Return the patient to the seated position.

Figure 6

Modified Gufoni's Maneuver



Note. (Nuti et al., 2016)

Privacy of personal data

Pseudonymisation is used to encode the collected date. The data is saved separately from the names of the participants, and it is ensured that outsiders cannot link these two. The results of a participant are linked to a random ID-number. The ID-number and the corresponding participants name are saved in a separate file. The UHasselt google drive is used to save this file. This drive is secured with a password that is only known by the doctoral student and the supervisor. The study outcomes, using the unique ID number will be stored in a separate document and guarded by an additional password protection. Access to both the password and the research findings are limited to the doctoral student and the supervisor. Any physical documents are securely kept in a locked cabinet located in the faculty building at the Health Campus Limburg DC , within the researcher's office. Furthermore, this office remains secured with a key when not in use.

Results

Subject characteristics

Table 1 shows the characteristics of the subjects analyzed (n = 47), consisting of 25 individuals with BPPV and 22 healthy individuals. The two groups were matched for mean age (p= 0.807), gender distribution (p= 0.706), mean height (p= 0.212) and mean weight (p= 0.634). Furthermore, no differences were found between the two groups for walking aid use (p= 0.175), number of comorbidities (p= 0.554) and sleep pattern (p= 0.335). The BPPV group used significantly more medication (p= 0.042) and achieved significantly lower scores for cognition (p= 0.002).

Table 1

Subject characteristics

The characteristics of the subjects

	Mean (SD)			Diff BPPV-CON P Value
	Total group	BPPV	CON	
Mean age	73.16 (4.84)	73.16 (4.89)	73.50 (4.53)	0.81
Height (m)	1.67 (0.08)	1.66 (0.09)	1.69 (0.06)	0.21
Gender (N/%)				0.71
Men	20 / 42.55%	10 / 40.00%	10 / 45.45%	
Women	27 / 57.45%	10 / 60.00%	12 / 54.55%	
Weight (Kg)	74.33 (10.20)	75.01 (11.64)	73.57 (8.49)	0.63
Sleep pattern (N/%)				0.34
Restless	12 / 25.53%	7 / 28.00%	5 / 22.73%	
Restless + takes a long time	3 / 6.38%	3 / 12.00%	0 / 0.00%	
Sleeps well	27 / 57.45%	13 / 52.00%	14 / 63.64%	
Takes a long time	5 / 10.64%	2 / 8.00%	3 / 13.64%	
Medication	4.00 (2.68)	4.64 (2.58)	3.27 (2.66)	0.04
Comorbidities	2.51 (1.33)	2.64 (1.41)	2.36 (1.26)	0.55
Cognition	25.09 (3.58)	23.56 (3.71)	26.82 (2.54)	0.002
Walking aid use (N/%)				0.18
No	45 / 95.74%	23 / 92.00%	22 / 100.00%	
Yes	2/ 4.26%	2 / 8.00%	0 / 0.00%	

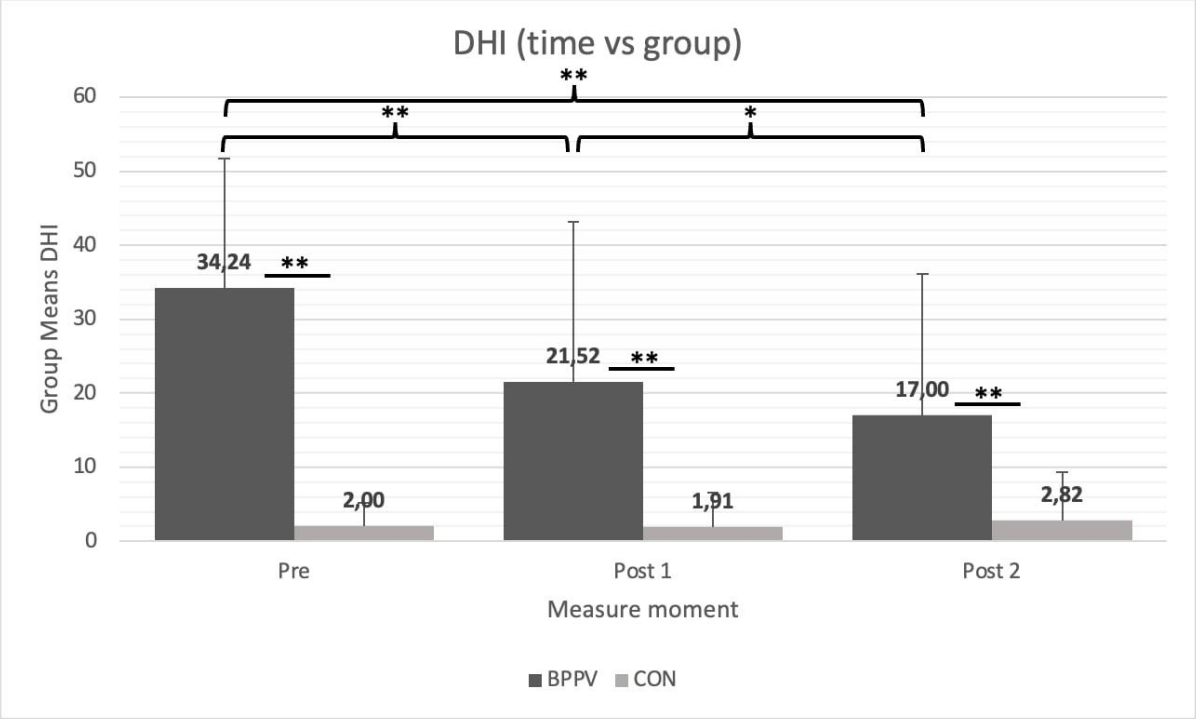
Note. BPPV = Benign Paroxysmal Positional Vertigo, CON= Control Group, SD= Standard deviation, mean (SD)

DHI

A significant interaction-effect was found for DHI (F= 12.46 & p= <0.001). Post-hoc comparison revealed that the DHI-score between the two groups was significantly higher in the BPPV group at all measure moments (pre: mean BPPV=34.24±17.42 vs mean CON=2.00±3.21, p= <0.001; post1: mean BPPV=21.52±21.68 vs mean CON=1.91±4.60, p= <0.001; post2: mean BPPV= 17.00±19.15 vs mean CON=2.82±6.52, p= 0.002). Post-hoc comparison revealed that within the BPPV-group a significant decreased DHI score was found between all measure moments (pre-post1: 34.24±17.42 - 21.52±21.68, p= <0.001; pre-post2: 34.24±17.42 - 17.00±19.15, p= <0.001; post1-post2: 21.52±21.68 - 17.00±19.15, p= 0.027). Post-hoc comparison revealed that within the control group no significant difference was found between all measure moments (pre-post1: p= 0.977; pre-post2: p= 0.773; post1-post2: p= 0.668). A significantly higher score means significantly more impact of dizziness on daily life. Figure 7 summarises the group means and significances.

Figure 7

Comparison DHI score between and within groups on different measure moments



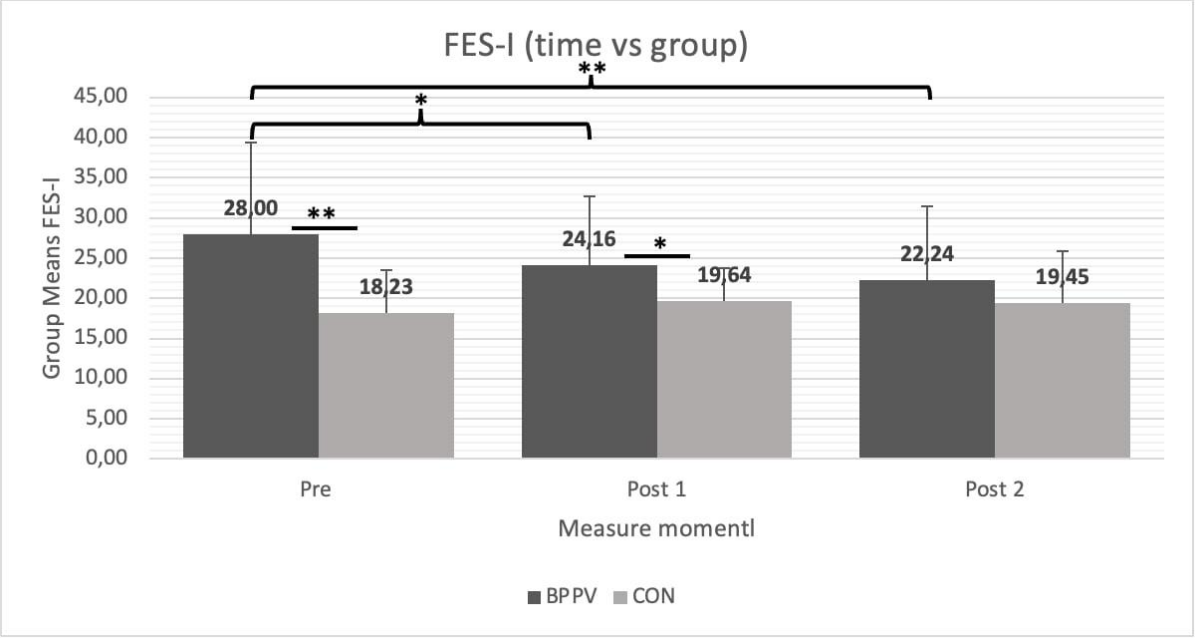
Note. This figure uses group means whitout considering the effect of covariates; DHI= Dizziness Handicap Inventory, BPPV= Benign paroxysmal Positional Vertigo, CON= Control, *= <0.05, **= <0.01, Error bars = standard deviations (SD)

FES-I

A significant interaction-effect was found for FES-I (F= 4.644 & p= 0.018). Post-hoc comparison revealed that at pre (Mean BPPV=28.00±11.43 vs mean CON=18.23±5.26, p= <0.001) and post1 (Mean BPPV= 24.16±8.53 vs mean CON=19.64±4.18, p= 0.029) a significant higher score was found between BPPV and control group, at post2 (Mean BPPV=22.24±9.16 vs mean CON=19.45±6.38, p= 0.239) no significant difference was found. Post-hoc comparison revealed that within the BPPV-group the scores significantly decreased between pre-post1 (28.00±11.43 - 24.16±8.53, p= 0.015) and pre-post2 (28.00±11.43 - 22.24±9.16, p= 0.006). For post1-post2 (24.16±8.53 - 22.24±9.16, p= 0.155) no significant difference was found in FES-I score. Post-hoc comparison revealed that within the control group no significant differences were found between all measure moments (pre-post1: p= 0.389; pre-post2: p= 0.564; post1-post2: p= 0.898). A significant higher score means significantly more fear of falling. Figure 8 summarises the group means and significances.

Figure 8

Comparison FES score between and within groups on different measure moments



Note. This figure uses group means whitout considering the effect of covariates; FES= Falls Efficacy Scale, BPPV= Benign Paroxysmal Positional vertigo, CON= Control, *= <0.05, **= <0.01, Error bars = standard deviations (SD)

GDS-15

Only a main effect of group was found for the GDS-15 (F= 8.134 & p= 0.007). This means that the BPPV group scored significantly higher than the control group (Mean BPPV= 3.19±4.09 vs mean CON= 1.14±1.46). The BPPV group experienced more depressive feelings than the control group. When looking at the main effect of time no significant effect was found (F= 0.285 & p= 0.696).

Mini-BESTest

Total score

No significant interaction-effect was found for the total score of the Mini-BESTest (F= 0.939 & p= 0.383). When looking at the main effect of time on the total score a significant effect was found (F= 6.628 & p= 0.003). Post-hoc comparison revealed a significant increase between pre-post1 (23.06±3.77 - 24.22±3.11, p= 0.010) and pre-post2 (23.06±3.77 - 24.46±2.53, p= 0.004), no significant difference was found between post1-post2 (24.22±3.11 - 24.46±2.53, p= 0.461). When looking at the main effect of group on the total score a significant effect was found (F= 8.904 & p= 0.005). The BPPV-group scored significantly lower than the control group (Mean BPPV= 22.65±3.82 vs mean CON= 25.17±2.45). A significant lower score means a significantly poorer balance.

Anticipatory postural control

No significant interaction-effect was found for anticipatory responses of the Mini-BESTest (F= 0.076 & p= 0.900). The main effect of time on anticipatory responses scores was not significant (F= 1.560 & p= 0.219). The main effect of group on anticipatory responses scores was not significant (F= 2.820 & p= 0.100).

Reactive Balance

No significant interaction-effect was found for reactive balance of the Mini-BESTest (F= 0.769 & p= 0.466). The main effect of time was significant (F= 3.784 & p= 0.026). Post-hoc comparison revealed a significant increase between pre-post2 (4.88±1.27 - 5.26±0.91, p= 0.021) and post1-post2 (4.89±1.43 - 5.26±0.91, p= 0.037), no significant difference was found between pre-post1 (4.88±1.27 - 4.89±1.43, p= 0.949). When

looking at the main effect of group on reactive balance scores a significant effect was found (F= 4.455 & p= 0.040). The BPPV-group scored significantly lower than the control group (Mean BPPV= 4.65±1.59 vs mean CON= 5.36±0.81). A significant lower score means a significantly poorer reactive balance.

Sensory Orientation

No significant interaction-effect was found for sensory orientation of the Mini-BESTest (F= 2.535 & p= 0.097). When looking at the main effect of time on sensory orientation scores a significant effect was found (F= 4.920 & p= 0.015). Post-hoc comparison revealed a significant increase between pre-post2 (5.59±0.76 - 5.88±0.30, p= 0.005), no significant difference was found between pre-post1 (5.59±0.76 - 5.82±0.58, p= 0.055) and post1-post2 (5.82±0.58 - 5.88±0.30, p= 0.386). When looking at the main effect of group on sensory orientation a significant effect was found (F= 5.154 & p= 0.028). The BPPV-group scored significantly lower than the control group (Mean BPPV= 5.57±0.88; mean CON= 5.95±0.21). A significant lower score means a significantly poorer sensory orientation.

Gait

No significant interaction-effect was found for gait on the Mini-BESTest (F= 0.282 & p= 0.721). When looking at the main effect of time on gait scores a significant effect was found (F= 4.936 & p= 0.013). Post-hoc comparison revealed a significant increase between pre-post1 (8.20±1.49 - 8.88±0.94, p= 0.011) and pre-post2 (8.20±1.49 - 8.64±0.98, p= 0.045), no significant difference was found between post1-post2 (8.88±0.94 - 8.64±0.98, p= 0.190). When looking at the main effect of group on gait a significant effect was found (F= 12.085 & p= 0.001). The BPPV-group scored significantly worse than the control group (Mean BPPV=8.13±1.42 vs mean CON=9.02±0.85)

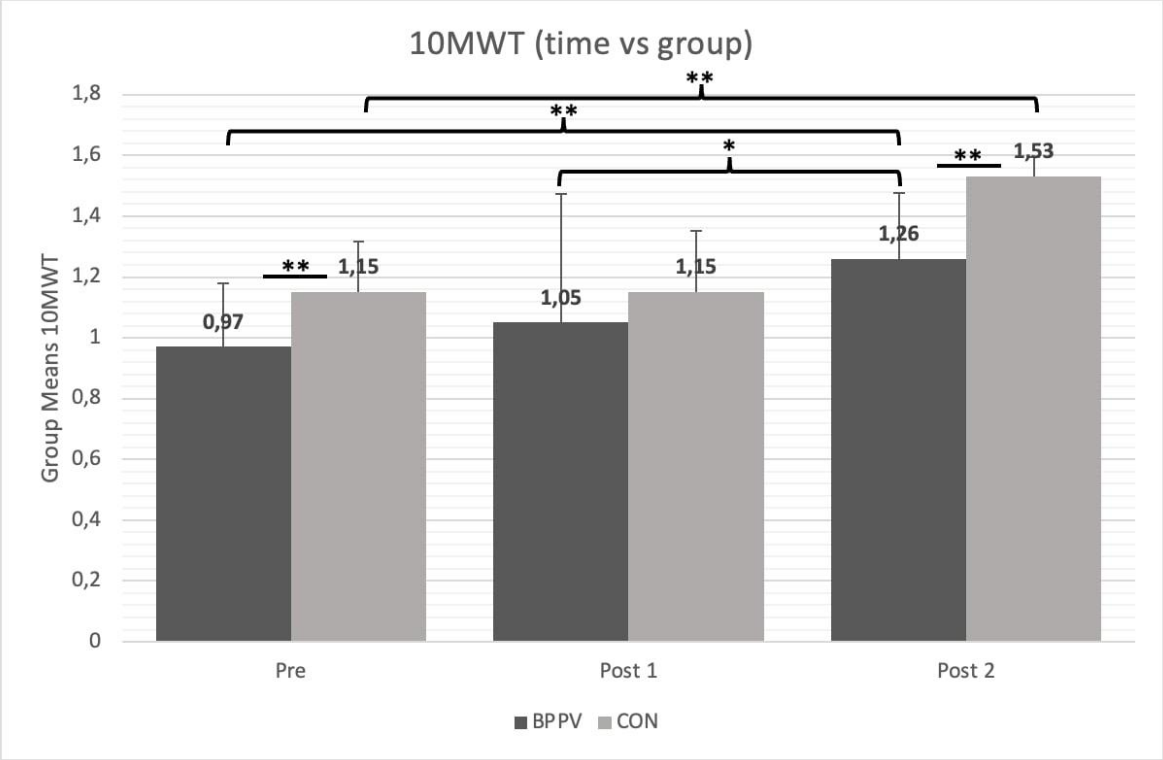
10 Meter Walk Test

A significant interaction-effect was found for 10MWT (F= 3.575 & p= 0.045). Post-hoc comparison revealed that at pre (Mean BPPV=0.97±0.21 vs mean CON=1.15±0.17, p= 0.003) and post2 (Mean BPPV=1.26±0.22 vs mean CON=1.53±0.06, p= <0.001) a significant higher

score was found in the BPPV group, at post1 (Mean BPPV=1.05±0.42 vs mean CON=1.15±0.20, p= 0.300) no significant difference was found. Post-hoc comparison revealed that within the BPPV-group a significant increase of the score was found between pre-post2 (0.97±0.21 - 1.26±0.22, p= <0.001) and post1-post2 (1.05±0.42 - 1.26±0.22, p= 0.013), no significant increase was found in 10MWT scores between pre-post1 (0.97±0.21 - 1.05±0.42, p= 0.148). Post-hoc comparison revealed that within the control group a significant increase was found between pre-post2 (1.15±0.17 – 1.15±0.06, p= <0.001), for post1-post2 (1.15±0.20 – 1.15±0.06, p= <0.001) no significant difference was found in 10MWT scores between pre-post2 (1.15±0.17 – 1.15±0.06 p= 0.942). A significantly lower score means a significantly slower gait speed. Figure 9 summarises the group means and significances.

Figure 9

Comparison score on the 10MWT between and within groups on different measure moments



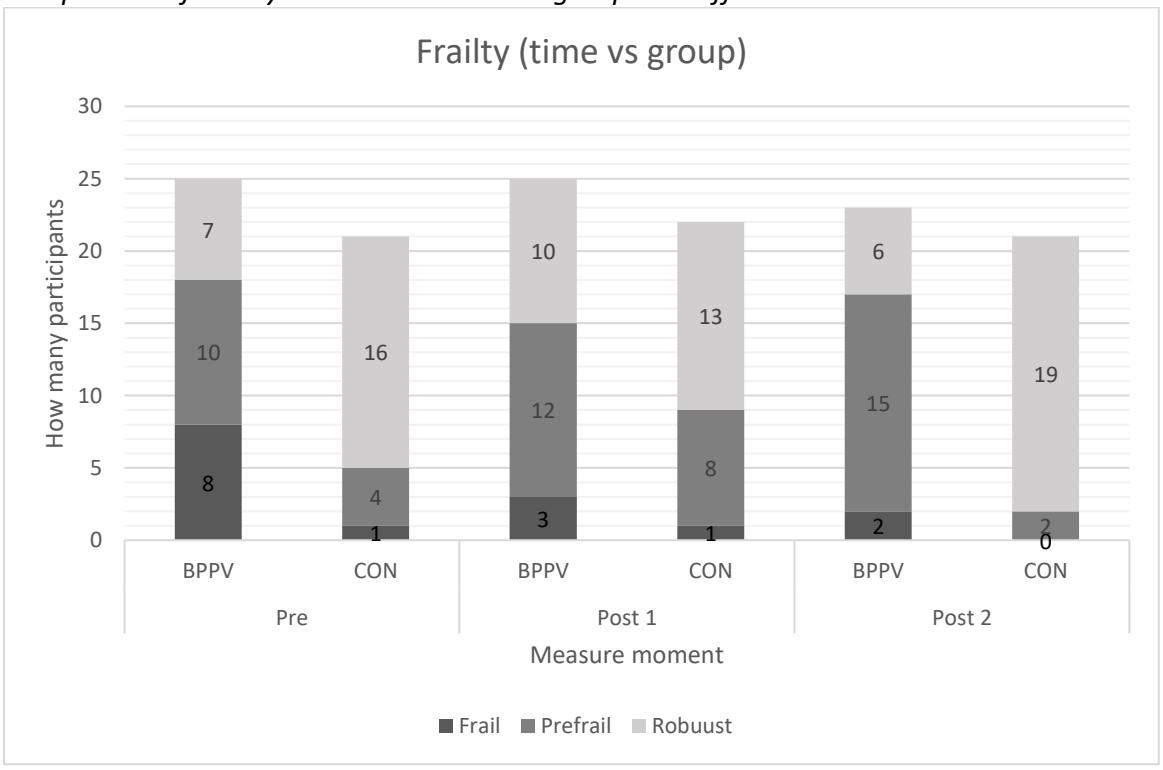
Note. This figure uses group means whitout considering the effect of covariates; BPPV= Benign Paroxysmal Positional Vertigo, CON= Control, 10MWT= 10 Meter Walk Test; *= <0.05, **= <0.01, Error bars = standard deviations (SD)

Frailty

A significant interaction-effect was found for frailty (F= 3.513 & p= 0.034). Post-hoc comparison revealed that at pre (p= 0.001) and post2 (p= <0.001) significant higher scores were found in the BPPV group, at post1 (p= 0.186) no significant differences were found. No significant differences were found at any of the measure moments within the BPPV group (pre-post1 p= 0.224; post1-post2 p= 1.000; pre-post2 p= 0.463). Post-hoc comparison revealed that within the control group no significant differences were found between all measure moments (pre-post1: p= 0.628; pre-post2: p= 0.784; post1-post2: p= 0.057). A significant higher score means a significantly more frail patient. Figure 10 summarises the group means and significances.

Figure 10

Comparison of Frailty between and within groups on different measure moments



Note. BPPV= Benign Paroxysmal Positional Vertigo, CON= Control, 10MWT= 10 Meter Walk Test

Discussion

BPPV symptoms, imbalance and dizziness, can have a substantial negative influence on a person's quality of life. Understanding the specific ways in which BPPV impacts daily activities and social interactions can be beneficial in gaining insight into the impact of the condition. This can be useful for further research and improving treatment. It is also essential to assess the efficacy of PRM's as treatment for BPPV in order to inform heathcare professionals. The effectiveness is evaluated by the effect on symptoms and quality of life. This study will provide a better understanding of BPPV and can lead to a more efficient treatment and a lower burden on the healthcare system. This study revealed several interesting findings.

Initially, the BPPV group scored significantly higher on the impact of dizziness compared to the control group. However, treatment with PRM significantly improved these scores after one and three months, although a significant difference between the groups persisted at three months. Fear of falling was also initially higher in the BPPV group but disappeared following three months of PRM treatment. The study by Hawke, Barr, and McLoughlin (2021) found no significant difference in FES-I scores between BPPV and controls (BPPV=36.70±11.40 vs CON=39.40±10.60, p= 0.481), whereas Cengiz et al. (2022) reported a significant difference (BPPV=40.63±11.45 vs CON=0.75±1.09, p= <0.001). The study by Song and Lee (2020) indicated that dizziness was strongly positively correlated with fear of falling; fear of falling increased as dizziness increased. It can be reasoned that an improvement in dizziness may cause fear of falling to decrease.

Walking speed, measured using the 10-Meter Walk Test (10MWT), was significantly lower in the BPPV group at the beginning of the study. This finding was confirmed by Pauwels et al. (2023), who also noted a significantly lower walking speed in the BPPV group. Pauwels et al. (2023) used the Timed Up and Go (TUG) instead of the 10MWT to measure gait speed. Although PRM significantly improved walking speed after three months, this improvement was not significant after one month, and a significant difference between the groups remained. The study by Reelick, van Iersel, Kessels, and Rikkert (2009) reflected that people with fear of falling have a lower walking speed, which may be a useful adaptation to improve balance.

General balance and gait improved significantly across the entire study population between pre-measurement and one month, and between pre-measurement and three months. However, the BPPV group had consistently lower scores. For reactive balance and sensory orientation, a significant improvement was found for the whole population between pre-measurement and three months. The BPPV group scored significantly lower on these parameters, although reactive balance also improved significantly between one month and three months. M. Zhu et al. (2023) found that older adults with BPPV scored lower on balance measures, including the total score of the Mini-BESTest (BPPV=17.95±5.53 vs CON=23.69±2.74), reactive balance (BPPV=3.18±1.68 vs CON=4.59±1.31), sensory orientation (BPPV=3.77±1.07 vs CON=5.67±0.72) and anticipatory control (BPPV=3.73±1.12 vs CON=5.14±0.99). No significant differences were found for gait (BPPV=7.27±2.47 vs CON=8.24±1.12 These results are all in line with our findings.

Frailty was significantly higher in the BPPV group at premeasurement, and PRM did not result in significant changes after one or three months. Xiao et al. (2022) suggested a causal relationship between vestibular disorders and frailty, highlighting the need for further research. Our findings reinforced this, as the level of frailty did not improve post-PRM, and BPPV patients were significantly more frail than the control group.

Depressive feelings remained higher in the BPPV group throughout the study. Previous research supports this finding; Ketola, Havia, Appelberg, and Kentala (2007) found that nearly 20% of patients with vertigo experience depressive symptoms. Monzani, Casolari, Guidetti, and Rigatelli (2001) also reported significant anxiety and depression in patients with vertigo, aligning with our results. An improvement of DHI scores in people with BPPV was positively correlated with changes in anxiety and depression, measured by the Hospital Anxiety and Depression Scale (HADS), according to C. Zhu, Li, Ju, and Zhao (2020).

The study by O'Reilly, Elford, and Slater (2000) demonstrated that PRM effectively improved Dizziness Handicap Inventory (DHI) scores across all BPPV subtypes. Similarly, Mutlu and Topcu (2022) reported DHI scores indicating a significant difference between BPPV (mean= 29.63 ± 23.67) and controls (mean= 1.12 ± 0.42) before treatment, supporting the findings of our study, which showed significant reductions in dizziness limitations in daily life with PRM.

Pauwels et al. (2023) performed a systematic review and meta-analysis, confirming PRM's effectiveness in reducing fear of falling and improving gait speed. This aligns with our study, which found improvements in fear of falling and gait between pre-measurement and three months, and between one month and three months.

In summary, while PRM significantly improves several parameters affected by BPPV, such as dizziness, walking speed, and fear of falling, other aspects like frailty and depressive feelings require additional interventions and further research to fully understand their impact.

For balance, frailty and depression, no studies were found that directly examined the effect of PRM. Because of the lack of existing studies an alternative search was necessary. A study confirming our findings about the improvement of dizziness was used to complete an alternative search for studies who describe the association with balance, frailty and depression in stead of using PRM. It can be deducted from the findings above that dizziness, fear of falling, slower walking speed and depressed feelings are a consequence of BPPV. We know that PRM is effective in treating BPPV, including the associated symptoms mentioned above.

This study showed several strengths, including the use of standardized measurement instruments: Mini-BESTest, 10MWT, DHI, FES-I, GDS-15 and Fried criteria adjusted by Avila-Funes. A consistent administration of tests by a single researcher was performed, this ensures uniformity in data collection. The use of standardized tests and a single researcher can improve the intra-rater reliability. In addition, the recruitment process included different groups “Senioren Universiteit Vlaanderen”, “OKRA Limburg”, “Happy Aging Bioville” and the network of researchers and patients themselves, improving the study’s ability to capture different perspectives. Clear inclusion and exclusion criteria were established, allowing a focused examination of relevant factors related to BPPV. Moreover, the study examined multiple aspects of BPPV, providing a comprehensive understanding of the condition. A power-analysis (power= 80.00% and alpha = 0,05) was performed to determine the sample size. The study included a sufficient amount of participants to meet the criteria of a good power. This means a higher likelihood of a hypothesis test detecting a true effect if there is one. It increases the reliability and decreases the chance of making a type II mistake, where a

true effect is missed. A control group was used, this increases the quality of the study because a comparison can be made and thus differences and normalization of outcomes can be evaluated.

However, this study also had several weaknesses. Despite the fact that it was a longitudinal study, it could only say something about effects up to three months, no statements could be made about long-term results. Further research is needed to determine the long-term effects. In addition, the use of subjective and non-standardized measuring instruments entailed a risk of measurement errors (measurement bias). The researcher was also not blinded to the groups and the measure moment, which in turn could also lead to measurement errors (experimenter bias). The use of different groups like “Senioren Universiteit Vlaanderen”, “OKRA Limburg”, “Happy Aging Bioville” and the network of researchers and patients themselves can also be a weakness. These are organisations where older adults voluntarly participate. In this way a more active part of the population was reached, which may not correspond to the BPPV group, which may be less active.

This study represented an attempt to evaluate the impact of BPPV and PRM on various factors. However, there are opportunities for further research and improvement. Specifically, this study revealed significantly higher medication use among the BPPV group compared to the control group, indicating a possible relationship between medication need or use and BPPV symptoms. Further research should study this correlation to explore the clinical implications. Moreover, the lower cognitive scores in patients with BPPV suggested a possible association between BPPV and cognitive decline that needs further investigation. This study also found that the BPPV group was more frail than the control group and that there was no improvement after three months with PRM. This is an opportunity to further explore this subject in future research to study the long term effects and the relation between Frailty and BPPV. In the results can be seen that several outcomes improved, but did not normalize. This can be an interesting topic for further research, to look for manners to normalize these outcomes.

In light of these findings, recommendations for further research include expanding the study duration, so long term conclusions can be made. Areas possibly related to BPPV, such as cognitive function and medication use, should be integrated into further research to optimize

rehabilitation protocols and patient outcomes. Sun et al. (2023) showed that vertigo and residual dizziness do not correlate with cognitive dysfunction but it needs more investigation. Future studies can contribute to a deeper understanding of BPPV and support more effective clinical interventions. Additionally, efforts should be directed towards translating research findings into clinical practice. Due to the results of this study, PRM can be recommended in the clinical practice as a short term treatment of BPPV symptoms (dizziness, fear of falling, balance and walking speed) in older adults.

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Appendix

Appendix 1

Mini Balance Evaluation Systems Test

Mini-BESTest: Balance Evaluation Systems Test

ANTICIPATORY ***SUB SCORE:*** /6

1. SIT TO STAND
Instruction: *"Cross your arms across your chest. Try not to use your hands unless you must. Do not let your legs lean against the back of the chair when you stand. Please stand up now."*
(2) Normal: Comes to stand without use of hands and stabilizes independently.
(1) Moderate: Comes to stand WITH use of hands on first attempt.
(0) Severe: Unable to stand up from chair without assistance, OR needs several attempts with use of hands.

2. RISE TO TOES
Instruction: *"Place your feet shoulder width apart. Place your hands on your hips. Try to rise as high as you can onto your toes. I will count out loud to 3 seconds. Try to hold this pose for at least 3 seconds. Look straight ahead. Rise now."*
(2) Normal: Stable for 3 s with maximum height.
(1) Moderate: Heels up, but not full range (smaller than when holding hands), OR noticeable instability for 3 s.
(0) Severe: ≤ 3 s.

3. STAND ON ONE LEG
Instruction: "Look straight ahead. Keep your hands on your hips. Lift your leg off of the ground behind you without touching or resting your raised leg upon your other standing leg. Stay standing on one leg as long as you can. Look straight ahead. Lift now."

Left: *Time in Seconds Trial 1:_____Trial 2:_____*
(2) Normal: 20 s.
(1) Moderate: < 20 s.
(0) Severe: Unable.

Right: *Time in Seconds Trial 1:_____Trial 2:_____*
(2) Normal: 20 s.
(1) Moderate: < 20 s.
(0) Severe: Unable

To score each side separately use the trial with the longest time.
To calculate the sub-score and total score use the side [left or right] with the lowest numerical score [i.e. the worse side].

REACTIVE POSTURAL CONTROL ***SUB SCORE:*** /6

4. COMPENSATORY STEPPING CORRECTION- FORWARD
Instruction: "Stand with your feet shoulder width apart, arms at your sides. Lean forward against my hands beyond your forward limits. When I let go, do whatever is necessary, including taking a step, to avoid a fall."
(2) Normal: Recovers independently with a single, large step (second realignment step is allowed).
(1) Moderate: More than one step used to recover equilibrium.
(0) Severe: No step, OR would fall if not caught, OR falls spontaneously.

5. COMPENSATORY STEPPING CORRECTION- BACKWARD
Instruction: "Stand with your feet shoulder width apart, arms at your sides. Lean backward against my hands beyond your backward limits. When I let go, do whatever is necessary, including taking a step, to avoid a fall."
(2) Normal: Recovers independently with a single, large step.
(1) Moderate: More than one step used to recover equilibrium.
(0) Severe: No step, OR would fall if not caught, OR falls spontaneously.

6. COMPENSATORY STEPPING CORRECTION- LATERAL
Instruction: "Stand with your feet together, arms down at your sides. Lean into my hand beyond your sideways limit. When I let go, do whatever is necessary, including taking a step, to avoid a fall."

Left
(2) Normal: Recovers independently with 1 step (crossover or lateral OK).
(1) Moderate: Several steps to recover equilibrium.
(0) Severe: Falls, or cannot step.

Right
(2) Normal: Recovers independently with 1 step (crossover or lateral OK).
(1) Moderate: Several steps to recover equilibrium.
(0) Severe: Falls, or cannot step.

Use the side with the lowest score to calculate sub-score and total score.

SENSORY ORIENTATION ***SUB SCORE:*** /6

7. STANCE (FEET TOGETHER); EYES OPEN, FIRM SURFACE
Instruction: "Place your hands on your hips. Place your feet together until almost touching. Look straight ahead. Be as stable and still as possible, until I say stop."
Time in seconds:_____
(2) Normal: 30 s.
(1) Moderate: < 30 s.
(0) Severe: Unable.

8. STANCE (FEET TOGETHER); EYES CLOSED, FOAM SURFACE

Instruction: "Step onto the foam. Place your hands on your hips. Place your feet together until almost touching. Be as stable and still as possible, until I say stop. I will start timing when you close your eyes."

Time in seconds:_____

(2) Normal: 30 s.
(1) Moderate: < 30 s.
(0) Severe: Unable.

9. INCLINE- EYES CLOSED

Instruction: "Step onto the incline ramp. Please stand on the incline ramp with your toes toward the top. Place your feet shoulder width apart and have your arms down at your sides. I will start timing when you close your eyes."

Time in seconds:_____

(2) Normal: Stands independently 30 s and aligns with gravity.
(1) Moderate: Stands independently <30 s OR aligns with surface.
(0) Severe: Unable.

DYNAMIC GAIT **SUB SCORE: /10**

10. CHANGE IN GAIT SPEED

Instruction: "Begin walking at your normal speed, when I tell you 'fast', walk as fast as you can. When I say 'slow', walk very slowly."

(2) Normal: Significantly changes walking speed without imbalance.
(1) Moderate: Unable to change walking speed or signs of imbalance.
(0) Severe: Unable to achieve significant change in walking speed AND signs of imbalance.

11. WALK WITH HEAD TURNS – HORIZONTAL

Instruction: "Begin walking at your normal speed, when I say "right", turn your head and look to the right. When I say "left" turn your head and look to the left. Try to keep yourself walking in a straight line."

(2) Normal: performs head turns with no change in gait speed and good balance.
(1) Moderate: performs head turns with reduction in gait speed.
(0) Severe: performs head turns with imbalance.

12. WALK WITH PIVOT TURNS

Instruction: "Begin walking at your normal speed. When I tell you to 'turn and stop', turn as quickly as you can, face the opposite direction, and stop. After the turn, your feet should be close together."

(2) Normal: Turns with feet close FAST (≤ 3 steps) with good balance.
(1) Moderate: Turns with feet close SLOW (≥4 steps) with good balance.
(0) Severe: Cannot turn with feet close at any speed without imbalance.

13. STEP OVER OBSTACLES

Instruction: "Begin walking at your normal speed. When you get to the box, step over it, not around it and keep walking."

(2) Normal: Able to step over box with minimal change of gait speed and with good balance.
(1) Moderate: Steps over box but touches box OR displays cautious behavior by slowing gait.
(0) Severe: Unable to step over box OR steps around box.

14. TIMED UP & GO WITH DUAL TASK ***[3 METER WALK]***

Instruction TUG: "When I say 'Go', stand up from chair, walk at your normal speed across the tape on the floor, turn around, and come back to sit in the chair."

Instruction TUG with Dual Task: "Count backwards by threes starting at ___. When I say 'Go', stand up from chair, walk at your normal speed across the tape on the floor, turn around, and come back to sit in the chair. Continue counting backwards the entire time."

TUG:_____seconds; Dual Task TUG:_____seconds

(2) Normal: No noticeable change in sitting, standing or walking while backward counting when compared to TUG without Dual Task.
(1) Moderate: Dual Task affects either counting OR walking (>10%) when compared to the TUG without Dual Task.
(0) Severe: Stops counting while walking OR stops walking while counting.

When scoring item 14, if subject's gait speed slows more than 10% between the TUG without and with a Dual Task the score should be decreased by a point.

TOTAL SCORE: /28

Note. (Franchignoni, 2010)

Appendix 2

Falls Efficacy Scale International

FES-I

We willen u graag enkele vragen stellen over hoe bezorgd u bent dat u zou kunnen vallen. Het gaat er hierbij om hoe u gewoonlijk deze activiteit uitvoert. Als u tegenwoordig deze activiteit niet doet (bijvoorbeeld omdat iemand anders voor u de boodschappen doet) willen we u vragen aan te geven hoe bezorgd u zou zijn om te vallen als u de betreffende activiteit toch zou doen. Wilt u voor elk van onderstaande activiteiten het antwoord aankruisen dat het beste weergeeft hoe bezorgd u bent om te vallen als u deze activiteit zou doen.

		Helemaal niet bezorgd 1	*Een beetje bezorgd 2*	*Tamelijk bezorgd 3*	*Erg bezorgd 4*
1	Het schoonmaken in huis (zoals vegen, stofzuigen of afstoffen)	*1* ☐	*2* ☐	*3* ☐	*4* ☐
2	Het aan- of uitkleden	*1* ☐	*2* ☐	*3* ☐	*4* ☐
3	Het klaarmaken van eenvoudige maaltijden	*1* ☐	*2* ☐	*3* ☐	*4* ☐
4	Het nemen van een bad of douche	*1* ☐	*2* ☐	*3* ☐	*4* ☐
5	Het doen van boodschappen	*1* ☐	*2* ☐	*3* ☐	*4* ☐
6	Het in of uit een stoel komen	*1* ☐	*2* ☐	*3* ☐	*4* ☐
7	Het op- of aflopen van een trap	*1* ☐	*2* ☐	*3* ☐	*4* ☐
8	Het maken van een wandeling in de buurt	*1* ☐	*2* ☐	*3* ☐	*4* ☐
9	Het reiken naar iets boven uw hoofd of naar iets op de grond	*1* ☐	*2* ☐	*3* ☐	*4* ☐
10	Het beantwoorden van de telefoon voordat deze ophoudt met overgaan	*1* ☐	*2* ☐	*3* ☐	*4* ☐
11	Het lopen op een gladde ondergrond (bijvoorbeeld nat of bevroren)	*1* ☐	*2* ☐	*3* ☐	*4* ☐
12	Het bezoeken van een vriend(in), kennis of familielid	*1* ☐	*2* ☐	*3* ☐	*4* ☐
13	Het lopen op een plek waar veel mensen zijn	*1* ☐	*2* ☐	*3* ☐	*4* ☐
14	Het lopen op oneffen ondergrond (zoals kinderkopjes of slecht onderhouden trottoir)	*1* ☐	*2* ☐	*3* ☐	*4* ☐
15	Het op- of aflopen van een helling	*1* ☐	*2* ☐	*3* ☐	*4* ☐
16	Het bezoeken van een sociale gelegenheid (zoals kerkdienst, familiebijeenkomst of verenigingsactiviteit)	*1* ☐	*2* ☐	*3* ☐	*4* ☐

FES-I Dutch translated from English by Prof Gertudis I.J.M. Kempen

Note. (Tinetti ME, 1990)

Appendix 3

Dizziness Handicap Inventory

Dizziness Handicap Inventory (DHI)

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Met *deze vragenlijst willen wij problemen of moeilijkheden die u ervaart vanwege uw duizeligheids- of evenwichtsklachten inventariseren.*

Instructies:

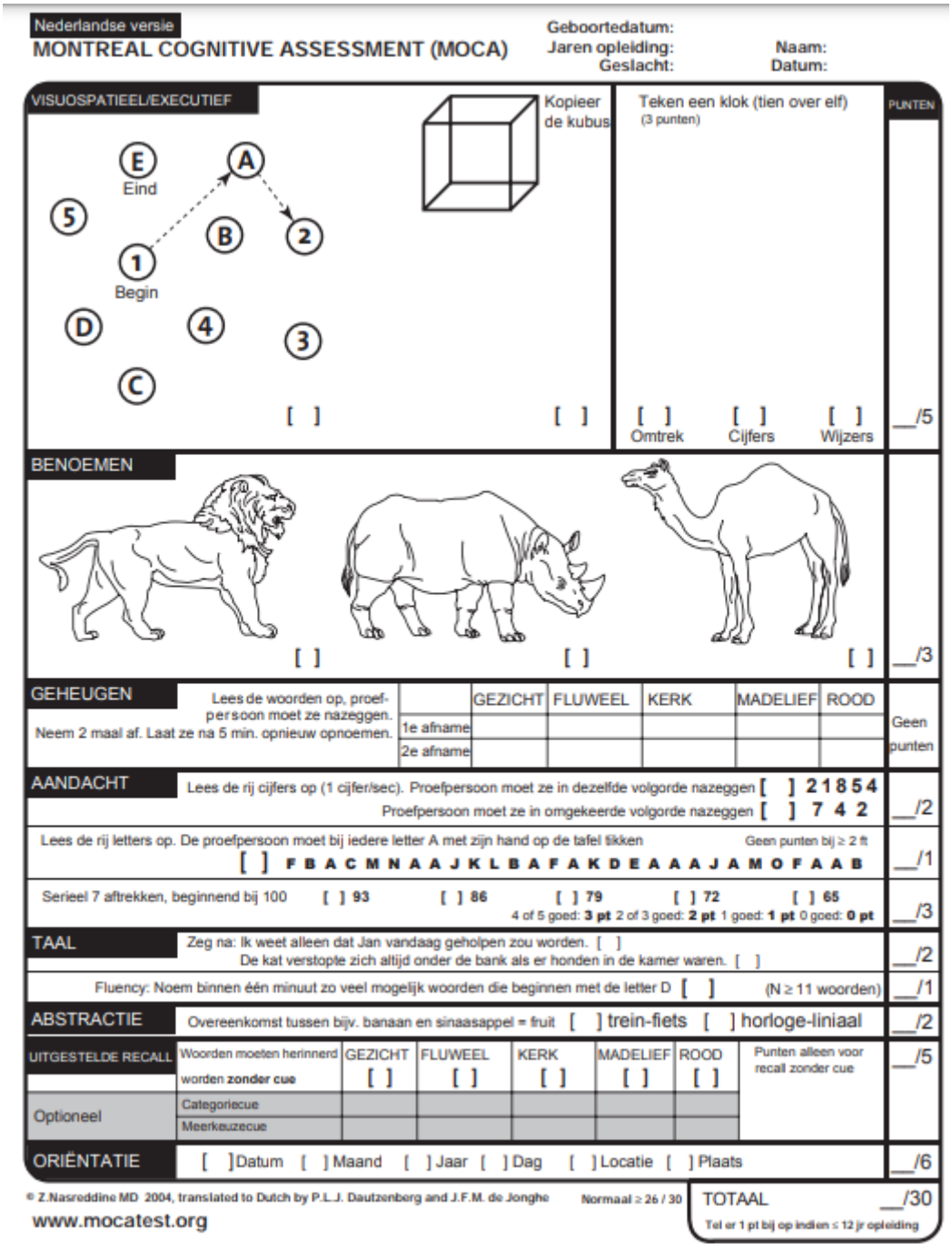
- Lees de vragen goed en beantwoordt elke vraag met vaak, soms of nooit door een kruisje(X) in het betreffende hokje achter de vraag te plaatsen.
- Beantwoordt elke vraag in relatie tot uw duizeligheidklachten. Bij twijfel plaatst u een kruisje(X) onder het antwoord dat het beste bij uw situatie past.

De volgende vragen beantwoorden alstublieft (kruis het goede hokje aan!)		Vaak	Soms	Nooit
P1	Verergeren uw klachten bij omhoog kijken?			
E2	Voelt u zich, vanwege uw klachten, gefrustreerd?			
F3	Worden uw privé- of dienstreizen beperkt door uw duizeligheidklachten?			
P4	Verergeren uw klachten bij lopen door het gangpad van de supermarkt?			
F5	Heeft u, vanwege uw klachten, moeite me het in of uit bed gaan?			
F6	Worden uw sociale activiteiten beperkt door uw klachten? (met sociale activiteiten wordt bedoeld: uit eten gaan, naar de film gaan, dansen, naar verjaardag/ feestjes gaan)			
F7	Heeft u vanwege uw klachten problemen met lezen?			
P8	Verergeren uw klachten bij meer belastende activiteiten zoals: sport, dansen en huishoudelijk werk *(zoals vegen, dweilen, de vaat opruimen, etc.)*?			
E9	Bent u, vanwege uw klachten, bang om zonder metgezel (alleen) het huis uitte gaan?			
E10	Bent u bij anderen in verlegenheid gebracht vanwege uw klachten?			
P11	Verergeren snelle hoofdbewegingen uw klachten?			
F12	Vermijdt u hoogten vanwege uw klachten?			
P13	Verergert omdraaien in bed uw klachten?			
F14	Is het moeilijk voor u, vanwege uw klachten, inspannend werk in huis of tuin te verrichten?			
E15	Bent u bang dat vanwege uw klachten mensen zullen denken dat u dronken bent?			
F16	Is het, vanwege uw klachten, moeilijk voor u om in uw eentje een wandeling te maken?			
P17	Verergeren uw klachten bij lopen op het trottoir?			
E18	Is het moeilijk voor u om u, vanwege uw klachten, te concentreren?			
F19	Is het, vanwege uw klachten, moeilijk voor u om in het donker door het huis te lopen?			
E20	Bent u bang om alleen thuis te zijn vanwege uw klachten?			
E21	Voelt u zich gehandicapt door uw klachten?			
E22	Hebben uw klachten tot stress of spanning geleid in uw relatie met familie of vrienden?			
E23	Bent u depressief vanwege uw klachten?			
F24	Beïnvloeden uw klachten uw taken binnen uw werk of huishoudelijke activiteiten?			
P25	Verergert vooroverbuigen uw klachten?			

Note. (Jacobson & Newman, 1990)

Appendix 4

Montreal Cognitive Assessment



Nederlandse versie

MONTREAL COGNITIVE ASSESSMENT (MOCA)

Geboortedatum:
Jaren opleiding:
Geslacht:
Naam:
Datum:

VISUOSPATIEEL/EXECUTIEF — PUNTEN

Kopieer de kubus

Teken een klok (tien over elf) (3 punten)

E Eind, A, 5, B, 2, 1 Begin, D, 4, 3, C

[ ] [ ] [ ] Omtrek [ ] Cijfers [ ] Wijzers — /5

BENOEMEN

[ ] [ ] [ ] — /3

GEHEUGEN

Lees de woorden op, proefpersoon moet ze nazeggen. Neem 2 maal af. Laat ze na 5 min. opnieuw opnoemen.

	GEZICHT	FLUWEEL	KERK	MADELIEF	ROOD
1e afname					
2e afname					

Geen punten

AANDACHT

Lees de rij cijfers op (1 cijfer/sec). Proefpersoon moet ze in dezelfde volgorde nazeggen [ ] 2 1 8 5 4 — /2

Proefpersoon moet ze in omgekeerde volgorde nazeggen [ ] 7 4 2

Lees de rij letters op. De proefpersoon moet bij iedere letter A met zijn hand op de tafel tikken. Geen punten bij ≥ 2 ft — /1

[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B

Serieel 7 aftrekken, beginnend bij 100 [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65 — /3

4 of 5 goed: **3 pt** 2 of 3 goed: **2 pt** 1 goed: **1 pt** 0 goed: **0 pt**

TAAL

Zeg na: Ik weet alleen dat Jan vandaag geholpen zou worden. [ ] — /2

De kat verstopte zich altijd onder de bank als er honden in de kamer waren. [ ]

Fluency: Noem binnen één minuut zo veel mogelijk woorden die beginnen met de letter D [ ] (N ≥ 11 woorden) — /1

ABSTRACTIE

Overeenkomst tussen bijv. banaan en sinaasappel = fruit [ ] trein-fiets [ ] horloge-liniaal — /2

UITGESTELDE RECALL

Woorden moeten herinnerd worden **zonder cue**	GEZICHT	FLUWEEL	KERK	MADELIEF	ROOD
	[ ]	[ ]	[ ]	[ ]	[ ]
Optioneel: Categoriecue					
Optioneel: Meerkeuzecue					

Punten alleen voor recall zonder cue — /5

ORIËNTATIE

[ ] Datum [ ] Maand [ ] Jaar [ ] Dag [ ] Locatie [ ] Plaats — /6

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Normaal ≥ 26 / 30

TOTAAL — /30

Tel er 1 pt bij op indien ≤ 12 jr opleiding

Note. (Dautzenberg PLJ, 2004)

Appendix 5:

Geriatric Depression Scale

Geriatric Depression Scale 15

GDS 15

Deze lijst bevat vragen waarop u met 'JA' of 'NEE' kunt antwoorden. Het is de bedoeling dat u de vragen leest en bedenkt welk antwoord u hierop zult geven. U geeft het antwoord dat het beste weergeeft hoe u zich de afgelopen week, met vandaag erbij, heeft gevoeld. Om het door u gekozen antwoord zet u een cirkeltje.

Naam: .....
Geboortedatum: .....
Datum invullen: .....

1. Bent u innerlijk tevreden met uw leven?	JA	NEE
2. Bent u met veel activiteiten en interesses opgehouden?	JA	NEE
3. Hebt u het gevoel dat uw leven leeg is?	JA	NEE
4. Verveelt u zich vaak?	JA	NEE
5. Hebt u meestal een goed humeur?	JA	NEE
6. Bent u bang dat u iets naars zal overkomen?	JA	NEE
7. Voelt u zich meestal wel gelukkig?	JA	NEE
8. Voelt u zich vaak hopeloos?	JA	NEE
9. Blijft u liever thuis dan uit te gaan en nieuwe dingen te doen?	JA	NEE
10. Hebt u het gevoel dat u meer moeite heeft met het geheugen dan anderen?	JA	NEE
11. Vindt u het fijn om te leven?	JA	NEE
12. Voelt u zich nogal waardeloos op het ogenblik?	JA	NEE
13. Voelt u zich energiek?	JA	NEE
14. Hebt u het gevoel dat uw situatie hopeloos is?	JA	NEE
15. Denkt u dat de meeste mensen het beter hebben dan u?	JA	NEE

Bron: Sheikh & Yesavage (1986)

Note. (Bleeker, 1985)