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Original article

GAIT IN PATIENTS WITH IMBALANCE SYNDROMES

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Abstract

Aim: (1) to establish which are the uses of vestibular reeducation procedure for patients with phobic postural vertigo (PPV), (2) to establish the mean leg length in meters (3) to establish the optimum kinetic programme in concordance with balance and gait scores after which the patient's symptoms will improve.

Methods: (1) reading the literature, (2) the different gait tasks were performed in a fixed order: walking with preferred speed, walking with slow speed, walking with fast speed, walking with a cognitive dual task, and walking with eyes closed, (3) observation, (4) tests: Activity-specific Balance Confidence Scale (ABC), (5) trials

Results: Our research was about gait performance and its relationship to the fear of falling and attention of PPV patients in a prospective study of 25 patients with PPV, mean age of 45 years.

We evaluated: gait parameters: the pace, rhythm, gait cycle, support and the dynamic stability domains of gait behavior

Conclusions: Our study tried to determine the role of exercise as a psychological support for patients with PPV. The gait of PPV patients is characterized by a reduction of walking speed which correlates with the fear of falling and dual tasks experiments reveal a higher attention demand for the gait task in PPV patients.

Key words: phobic postural vertigo, exercise, gait parameters.

Introduction

Phobic postural vertigo (PPV) is the most common cause of chronic dizziness in middle-aged patients. Many patients report symptoms involving gait. We investigated the gait performance and its relationship to the fear of falling and attention of PPV patients in a prospective study of 25 patients with PPV. Subjects walked at three different speeds (slow, preferred, fast), both during cognitive dual tasks (DTc) and with eyes closed (EC). Falls efficacy and balance confidence were rated by the Falls Efficacy Scale-International (FES-I) and the Activities-specific Balance Confidence Scale (ABC). PPV patients walked slower, with reduced cadence and stride length and increased double support at all patients. These changes correlated with results of FES-I. Walking deterioration was observed at all patients under DTc, with a reduced cognitive processing speed, men being more affected than women. When walking with EC, gait speed decreased at all patients. Patients with PPV show gait changes which correlate with their fear of falling and balance confidence.

The syndrome of phobic postural vertigo (PPV) is characterized by subjective dizziness and disturbance of balance. However, these patients have normal values in clinical balance tests (Brandt, 1996). It can be classified among the primary and secondary somatoform dizziness syndromes, which are also termed visual vertigo syndrome (Bronstein, 1995) or chronic subjective dizziness (Staab, Ruckenstein, 2007). The visual vertigo syndrome covers symptoms that are regularly provoked during or after moving visual environmental stimuli, whereas PPV often presents symptoms which are not directly associated to such stimuli. Moreover, PPV differs from chronic subjective dizziness by the presence of phobic avoidance behavior. One-third of the PPV patients further present panic attacks associated with vertigo and dizziness.

PPV is one of the most frequent causes of chronic dizziness (Best, et al. 2006, Eckhardt-Henn, et al. 2003, Furman, Jacob, 1997) and represents an important entity in the differential diagnosis of chronic dizziness disorders. It has a great impact on functioning and quality of life (Best, et al. 2006). A negative correlation between the duration of the condition before diagnosis and the improvement of symptoms (Brandt, Huppert, Dieterich, 1994) indicates that an early identification of typical symptoms is essential for the successful treatment of PPV patients.

The majority of PPV patients report having balance disturbances, mainly while walking and standing, with exacerbation during perceptional stimuli (e.g., walking on a bridge, walking stairs, walking in empty rooms) and during social situations (crowds, supermarkets, concerts, restaurants). Typically, PPV follows a period of particular emotional stress or vestibular or non-vestibular illness. While the stance behavior of PPV patients has been intensively investigated (Brandt, et al. 2012, Bronstein, 1995, Dieterich, 2001; Holmberg, 2009; Krafczyk, 1999; Querner, 2002; Tjernstorm, 2009), little is known

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about changes in gait control of these patients.

The aim of this study was to determine gait changes of patients with PPV and to evaluate whether these changes are associated with their subjective imbalance and fear of falling. Spatial and temporal gait variables, and variability markers, as well as the correlations to subjective fear of falling and balance confidence measures, were analyzed. Since gait abnormalities in patients with vertigo and dizziness depend on walking speed (Brandt, Strupp, Benson, 1999; Schniepp, 2012), walking behavior was examined at different walking speeds.

Materials and methods

Twenty-five patients with PPV (12 women; mean age 54 ± 13 years; mean height: 1.67 ± 0.12m; mean weight: 75.6 ± 4.2 kg and 13 men; mean age 57 ± 11 years; mean height: 1.77 ± 0.11m; mean weight: 82.4 ± 5.2 kg) participated in the observational group. The diagnosis of PPV was based on the diagnosed criteria proposed by Brandt (Best, 1996).

Patients underwent a standardized diagnostic work-up. Afferent somatosensory deficits were excluded by testing vibrotactile sensitivity, surface sensibility, and acrognosis. Vestibular testing included head-impulse test of the horizontal vestibulo-ocular reflex (Halmagyi, Curthoys, 1988). All subjects were found to have normal somatosensory and vestibular functions.

Gait analysis was performed using at treadmill. All patients had to walk over the band at three different speeds (preferred, slow and maximally fast). Gait was then examined while walking at the preferred speed and performing a cognitive dual task (DTc) (serial 7 task) with the instruction to focus on the cognitive task. Afterwards walking at the preferred speed with eyes closed (EC) was examined. The different gait tasks were performed in a fixed order: walking with preferred speed, walking with slow speed, walking with fast speed, walking with a cognitive dual task, and walking with eyes closed. Each walk was started 1.5 m in front of the mat and continued for 1.5 m beyond it in order to allow steady-state locomotion. Each task was tested twice. During the serial 7 dual task, the calculation steps and the time from the beginning to the end of the condition were documented. The Functional Gait Assessment (FGA), a 10-item gait test developed for patients with balance deficits and vestibular disorders (Wrisley, 2004), was used to clinically assess the gait capacity and the Berg Balance Scale (BBS) to assess balance (Berg, 1992).

All patients competed the Falls Efficacy Scale-International (FES-I) and the Activity-specific Balance Confidence Scale (ABC) as described elsewhere [Greenberg SA 2012]. The FES-I compares 16 questions on the subjective fall efficacy in daily life situations. A total score is obtained by adding the scores (1 – 4) of each question. That will give a range from 16 (no concerns about falling) to 64 (severe concerns about falling) points. The ABC is a self-reported questionnaire of 16 questions evaluating the subject's level of self-confidence in daily mobility situations.

The following standard gait parameters were analyzed: Functional Ambulation Profile (FAP) as described elsewhere [32], velocity, cadence, stride time, stride length, and base of support as markers for the magnitude of gait variability. These gait parameters comprehensively represent the pace, rhythm, gait cycle, support and the dynamic stability domains of gait behavior (for overview see (Lord, 2013).

Results

Characteristics of the enrolled subjects

Basic demographics and patient characteristics are summarized in Table 1. The PPV cohort had a mean age of 49 ± 15 years and a mean duration of symptoms of 47 months (range 2; 180). Six patients showed a secondary form of PPV, i.e., an episode of vertigo or dizziness preceded the PPV symptoms (Table 1). Seventeen of the 18 patients with a primary PPV course reported that an unspecific situation or stress or a non-vestibular disease preceded the symptoms.

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Table 1 Demographic and clinical data of the enrolled subjects

PPV	Men	Women
Basic demographic information		
Gender female:male	13	12
Mean age in years	54 ± 13	57± 11
Mean leg length in meters	0.88 ± 0.10	0.86 ± 0.10
Mean height in meters	1.67 ± 0.12m	1.77 ± 0.11m
Mean duration of symptoms in months	45 ± 3	44± 41
Primary	8	7
Secondary	5	5
Benign paroxysmal positional	2	1

vertigo		
Vestibular migraine	1	1
Whiplash trauma	1	0
Dizziness and subjective balance problems	13	12
Attacks with exacerbation of symptoms	12	13
Anxiety and vegetative symptoms	13	12
Exacerbation dependent on perceptional stimuli or social situation		
Improvement when attention is drawn away	10	8
Obsessive-compulsive personality	2	3
Onset following a period of stress or illness	11	12
Balance and gait scores		
Median FGA [points] with min; max	22(12,31)	23(11, 30)
Median BBS [points] with min; max	6(3,8)	7 (2, 8)
Median FES-I [points] with min; max	26 (15; 59)	26 (16; 57)
Mean ABC [%] with min; max	72.3 (22; 98)	73.4 (20; 100)

PPV patients with phobic postural vertigo, FGA functional gait assessment, BBS Berg balance scale, FES-I falls efficacy scale-international, ABC activity-specific balance confidence scale

Anxiety during balance situations was reported or admitted on direct questioning by 25 patients, men more than women whereas vegetative symptoms such as palpitations, sweating, dyspnea or diarrhea were present in 25 patients. Only 2 men and 3 women had a history of coexisting panic disorder and/or agoraphobia. 25 patients reported observing an avoidance behavior in triggering situations, i.e., open spaces, enclosed spaces like elevators, crowds and bridges. The FGA revealed mild to moderate gait impairments with a median of 22(12,31) for the men PPV and 23(11, 30) for women PPV. FES-I with a median score of 26 (15; 59) for men and 26 (16; 57) for women. The ABC with a mean of 72.3 (22; 98) for men and 73.4 (20; 100) for women showing a wide range covering moderate to severe fear of falling and balance uncertainty.

These measures did not correlate with the duration of symptoms. Twenty-one patients had no history of falls in the previous 6 months (3 patients had fallen once).

Gait characteristics of PPV patients

Band walking testing revealed a significant reduction of walking speeds in PPV patients under the conditions of walking at slow speed, the cadence and stride length of PPV patients were reduced We found no significant changes of the base of support and of temporal and spatial gait variability markers between male and female patients. Walking at maximum speed did not reveal a significant difference in walking speed between the two groups. A slight but significant reduction of cadence at women PPV patients was found. None of these gait parameters showed a significant correlation with the duration of the symptoms. Walking characteristics during cognitive dual task or with eyes closed.

The addition of a DTc (subtracting 7) while walking caused changes of gait parameters in both PPV (men and women) patient groups: a slight reduction of walking speed, cadence and stride length with an increase of gait cycle parameters (stride time, double support percentage) and gait variability parameters could be detected.

Walking with eyes closed also revealed parallel changes in the walking patterns PPV patients: walking speed was reduced with a decrease in cadence and stride length and an increase in gate cycle parameters (stride time) and gait variability. Calculation of the VR revealed that the reduction in walking speed, cadence and stride length was more pronounced in female PPV patients compared to male PPV patients.

No significant correlations were found for FES-I, ABC, and the VR for different gait parameters under walking with eyes closed.

Discussions

Our main findings are as follows:

1. The gait of PPV patients is characterized by a reduction of walking speed which correlates with the fear of falling.
2. Dual tasks experiments reveal a higher attentional demand for the gait task in PPV patients, independent of sex of them.
3. PPV patients rely more on visual feedback while walking.

The gait of PPV patients was characterized by changes in pace, rhythm, and gait cycle variables. The most prominent change in the walking pattern of PPV patients was a reduction of walking speed during slow and preferred walking, during walking with DTc; and during walking with EC. The decrease in cadence and stride length and the increase in double support phases can be attributed to the overall reduction of walking speed. How can this reduction of walking speed be test explained? Studies on patients with mixed vestibular entities demonstrated a reduction of walking speed, which was considered a compensatory strategy of these patients in order to increase dynamic equilibrium (Perring, Summers, 2007). However, studies with homogenous patients cohorts found preserved walking speeds in patients with reduced afferent sensory imputs (Bessot, et al. 2012; Cohen, et al. 2012). In general, gait impairments due to impaired sensory function are most evident during slow walking (Brandt, et al. 1999; Jahn, 2000). FMRI studies of locomotor imagery revealed a decrease of vestibular and somatosensory cortex activation during running compared to walking (Jahn, et al. 2008). Based on the mentioned studies, it has been supposed that slow walking modes exhibit a higher dependence on sensory feedback than fast walking modes do. Fast walking or running are governed by a highly automated control of central pattern generators (CPG) according to the models of a hierarchical locomotion network (Dimitrijevic, 1998). Afferent somatosensory information has the strongest influence on the CPG operation during fast walking or running, when proprioceptive and cutaneous pressure information are most pronounced (Duysens, et al. 1991). In this respect, the observed reduction of walking speed (during preferred and slow walking) in patients with PPV suggests a modification of their walking control. It implies a shift of gait control towards a more active, visual-vestibular-based control scheme. This is in accordance with recent posturographic studies on stance control schemes demonstrating that patients with PPV apply more actively controlled and sensory weighted feedback loops under normal standing conditions (Schniepp R, 2013). A shift away from this control scheme might occur during maximally fast walking, which is associated with a highly automated gait pattern mostly independent from visual and vestibular control. Therefore, future PPV intervention studies should investigate whether a therapeutically induced acceleration of gait might be beneficial for PPV patients.

An alternative explanation for the reduction of walking speed in PPV patients can be extracted from the concept of "cautious gait", an established term in the field of geriatric gait research (Gilady, 2005). "Cautious gait" is typically marked by mild to moderate slowing reduced stride length and mild widening of the base of support (Nutt, et al. 1993). Anxiety-related factors and the fear of falling are major contributors to a cautious gait. Some authors also state that a reduction of the walking speed increases the possibility for conscious gait control (Aizen, 2001). Correlation analysis in our PPV cohort supports this theory; PPV patients showed significant correlations between gait speed reduction and the subjective fear of falling (FES-I) and the scores for balance confidence (ABC).

In contrast to patients with vestibular deficits (e.g. bilateral vestibular loss) (Schniepp, 2012) or patients with cerebellar disorders (Wuehr, 2013), we found normal values of temporal and spatial gait variability parameters in PPV patients. Gait variability which represents the stride-to-stride fluctuations of the walking behavior is a useful marker of dynamic stability during gait (Hausdorff, 2005). The distinct characteristics of gait variability in PPV patients on one side and somatic dizziness entities on the other side might be used in the differential diagnosis in patients with chronic dizziness during stance and gait. Gait variability measurements might be helpful in geriatric balance centers where gait analysis is more widely used than neuro-otological testing procedures (e.g. caloric testing of vestibular function).

A current concept of postural control is that it shares attentional resources with cognition (Kerr, 1985). Dual task paradigms, employing walking and cognitive tasks simultaneously, have been used to shed light on motor and cognitive interference with gait (Woollacott, 2002). Whereas the decrement of gait quality in our study was similar for PPV women and men (indicated by comparable VR in both groups), we found significant differences in the performance of the second, non-postural task; PPV patients showed a reduced cognitive processing speed under DTc, which denotes a disturbed dual task capacity in these patients. Changes of the non-postural task in DTc paradigms can be considered to indirectly reflect the attentional demands of posture, (Ebersbach, 1995) which would then support the hypothesis that PPV patients pay more attention to gait control than do HS. On the other hand, one could argue that the obsessive-compulsive personality of a PPV patient per se could have influenced the performance of a cognitive task and that the reduced processing speed is not specific for dual task situations. This is unlikely, as the clinical contact with PPV patients does not support the idea of a general reduced cognitive processing speed. However, it cannot be ruled out completely, since the current study lacks a control condition with a cognitive single task. To elucate this aspect, future studies should include comprehensive single and dual task conditions in order to further investigate additional demands of gait control in PPV patients.

Decrements of cognitive rather than postural tasks yield information on the prioritization of tasks in DTc situations. Although the PPV patients were instructed to give priority to the cognitive task, the patients rather focused on good postural control instead of a good performance of the cognitive task. Thus, the main focus of PPV patients lies on the maintenance of postural stability, which might explain why they do not actually fall despite their high scores for fear of falling.

Walking with eyes closed revealed a pronounced reduction of walking speed and higher individual VR in PPV patients. This indicates that PPV patients rely more on visual imputs during walking than do HS, a fact that agrees with the concept of visual vertigo (Bronstein, 1995). This phenomenon was independent from the duration of symptoms and did not show any correlations to the subjective fear of falling. The weighting of sensory imputs of PPV patients seems to be shifted toward the visual system. The sensory shift towards the visual system also explains the common observation that PPV patients experience exacerbations of their complaints in situations requiring complex visual information processing (moving visual scenes, open spaces).

Conclusions

PPV patients show characteristic gait alterations: a reduced gait speed and consequent impairments of the pace, rhythm and gait cycle variables. This changes correlate with the patients' subjective fear of falling. Moreover, dual-task and eyes closed walking paradigms suggest that walking in PPV patients is characterized by an increased attentional control and a higher reliance on visual imput.

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