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Diminished Dynamic Physical Performance Is Associated With Orthostatic Hypotension in Geriatric Outpatients

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ABSTRACT

Background and Purpose: Orthostatic hypotension (OH), a blood pressure drop after postural change, is a highly prevalent and disabling syndrome in older adults. Yet, the association between physical performance and OH is not clearly established. The aim of this study was to determine whether different types of physical performance are associated with OH in a clinically relevant population of geriatric outpatients.

Methods: This cross-sectional study included 280 geriatric outpatients (mean age: 82.2 years, standard deviation: 7.1). Orthostatic hypotension was determined using intermittently measured blood pressure and continuously measured blood pressure in a random subgroup of 58 patients. Physical performance was classified into a dynamic type (4-m Walk Test, Chair Stand Test, and Timed Up and Go test) and a static type (standing balance tests, handgrip strength). Associations were analyzed using logistic regression models with adjustments for age, sex, weight, and height.

Results: Diminished physical performance on the Chair Stand Test was associated with OH measured intermittently. Diminished physical performance on all dynamic physical domains (4-m Walk Test, Chair Stand Test, and Timed Up and Go test) was associated with OH measured continuously. Static physical performance was not significantly associated with OH.

Conclusion: Dynamic physical performance tests with a substantial postural change and center of mass displacement were significantly associated with OH. The influence of physical performance on OH in daily routine activities should be further explored to establish counteracting interventions.

Key Words: blood pressure, blood pressure monitors, geriatric assessment, orthostatic hypotension, physical performance

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INTRODUCTION

Orthostatic hypotension (OH) is prevalent in approximately 30% of community-dwelling older adults and up to 70% of older adults in nursing homes.[1] The prevalence is reported to be even higher when blood pressure (BP) is measured continuously instead of intermittently.[2] Orthostatic hypotension is defined as a drop in BP of at least 20 mm Hg systolic and/or 10 mm Hg diastolic BP at 1 and 3 minutes after postural change.[1] Initial OH (iOH), a BP drop of at least 40 mm Hg systolic and/or 20 mm Hg diastolic BP within 15 seconds after postural change, also proved to be a clinically

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relevant parameter[3] and is present in more than 30% of older adults.[2] Orthostatic hypotension is associated with a higher risk of cardiovascular events and mortality[4] and can be significantly disabling due to symptoms of dizziness, lightheadedness, and instability.[1] Two to 10% of all falls occur as a result of abnormal BP responses such as OH.[5,6]

A recent prospective study in community-dwelling older adults showed an association between OH, assessed with continuously measured BP, and falls.[7] No association was found between OH assessed with intermittently measured BP and falls.[7] This indicates the importance of measuring OH continuously and the contribution to physical disability. Another study in community-dwelling older adults has found an association between orthostatic intolerance, but not OH, and physical frailty, which incorporated 2 entities of physical performance, that is, dynamic and static physical performance.[8] To the best of our knowledge, the type of physical performance (dynamic vs static) has not been studied in relation to OH in geriatric outpatients.

The aim of this study was to determine whether dynamic physical performance with a substantial postural change hence with a clear center of mass (CoM) displacement associates with iOH and OH in geriatric outpatients compared with static physical performance without a postural change. It can be hypothesized that physical performance with a substantial postural change, that is, with a displacement of the CoM, associates with OH as this type of physical performance may explicitly provoke BP decrease in patients with OH and therewith a worse performance.

METHODS

Study Design

This cross-sectional study included 299 community-dwelling older adults who were referred to the geriatric outpatient clinic of a middle-sized teaching hospital (Bronovo Hospital, The Hague, the Netherlands) due to mobility problems, between October 2010 and January 2012. No exclusion criteria were applied; inclusion was based on referral. A comprehensive geriatric assessment was performed by trained nurses including questionnaires, physical performance tests, and cognitive assessment during the first visit,[9] incorporating the evaluation of the physical, cognitive, psychosocial, and environmental factors influencing the older adults in their well-being.[10] In 280 geriatric outpatients, data on intermittently measured BP were available. In a consecutive subgroup of 62 outpatients, BP was also measured continuously using a Finometer (Finometer PRO, Finapres Medical Systems BV, Amsterdam, the Netherlands) due to a protocol amendment in which the continuously measured BP was added in a later stage. Data of 4 patients were excluded because of technical errors, resulting in 58 outpatients for the subgroup analyses.

This study was reviewed by the Committee of Medical Ethics (institutional review board) of the Leiden University Medical Center, the Netherlands. Informed consent was waived as all measurements were based on standard clinical care.

Geriatric Outpatient Characteristics

Questionnaires were used to obtain information on marital status, living arrangements, education, and alcohol use. Highly educated was defined as having a university degree. Excessive alcohol use was defined as more than 14 units per week for females and more than 21 units per week for males; a unit was defined as a standard glass appropriate for the type of alcohol. Information on age and medical history was obtained from medical charts. Multimorbidity was defined as presence of 2 or more diseases of the following: chronic obstructive pulmonary disease, diabetes mellitus, hypertension, malignancy, myocardial infarction, Parkinson's disease, and rheumatoid or (osteo) arthritis. For determining body mass index, height and weight on a weighing scale were measured to the nearest 0.1 decimal. The Mini-Mental State Examination was used to determine global cognitive performance of the patients.[11]

Physical Performance

Dynamic physical performance

The 4-m Walk Test was performed at a usual pace, starting from a standing position and timed over a standardized 4-m distance. Timing started when the first whole foot touched the floor after the starting line and ended when the first whole foot touched the floor after the 4-m line. The fastest time of the 2 performances was used for the present analysis.

The Chair Stand Test (CST) included a timed 5 times sit to stand starting in sitting position and ending when the patient touched the seat with the buttocks on the last repetition. Patients were instructed to perform the test as fast as possible. Standing up was performed using a standardized chair adjusted to attain 90° flexion in the patient's knee joint without the use of the hands.

The Timed Up and Go (TUG) is a timed walking test performed at a usual pace, starting from the moment patients were in the sitting position, followed by standing up without the use of arms (arms crossed to the shoulders), walking around a cone placed 3 m from the chair, and stopping at the moment patients were sitting down in the original starting position.[12]

All dynamic physical performance tests were expressed in seconds. The tests were preferably performed without the use of an ambulatory device; only when it was not possible to perform the test without and used in daily life, ambulatory assistive devices were allowed. Patients who were not able to perform the tests or used hands during the tests were given a time score of 100 seconds to be able to include these patients in the analysis.

Static physical performance

Patients were asked to maintain standing balance during 10 seconds with eyes open in 3 different positions: side-by-side, semitandem, and tandem stance.[13] Patients were classified as able to maintain standing balance during 10 seconds or as not able to maintain standing balance during 10 seconds.

Muscle strength was quantified by handgrip strength, a measurement which is frequently used as a measure of overall muscle strength. Handgrip strength was measured in standing position with the arm in extension parallel to the body, using a handheld hydraulic dynamometer (Jamar, Sammons Preston, Inc, Bolingbrook, Illinois).[13] Patients were encouraged to squeeze as hard as possible. The best performance of 3 trials alternately for each hand was used for the analysis and was expressed in kilograms.[15]

Orthostatic Hypotension

Blood pressure was measured in supine position after a resting period of at least 5 minutes and in standing position after a period of 1 and 3 minutes after postural change and was performed in a standardized way by trained nurses. An automatic lift chair (Vario 570, Fitform BV, Best, the Netherlands) supported the transition from supine position to standing position. After reaching the standing position, patients were asked to stand upright unsupported for 3 minutes.

Intermittently measured BP

Systolic BP and diastolic BP were measured with an automated sphygmomanometer on the left arm with the arm held alongside the body (Welch Allyn, Skaneateles, New York). The following measurements were obtained to assess OH: (i) supine BP after 5 minutes of rest; (ii) BP measured at both 1 and 3 minutes after standing up; and (iii) BP decrease at both 1 and 3 minutes after standing up compared with supine BP. $OH_{intermittently}$ was defined as a decrease of at least 20 mm Hg systolic BP and/or 10 mm Hg diastolic BP at 1 and/or 3 minutes after standing up compared with supine BP.[1]

Continuously measured BP

Continuously measured BP was obtained with a digital photoplethysmograph (Finometer PRO, Finapres Medical Systems BV, Amsterdam, the Netherlands), with a cuff placed on the right middle finger, simultaneously with the sphygmomanometer on the left arm, while holding both arms alongside the body. Beat-to-beat BP data were analyzed using BeatScope 1.1 software (Finapres Medical Systems BV, Amsterdam, the Netherlands). Data were subsequently exported to Matlab (version R2012b, the Mathworks, Natick, Massachusetts). Beat-to-beat BP data were averaged over 5 seconds of intervals.[16] The following BP measurements were obtained to assess $OH_{continuously}$: (i) supine BP, defined as the mean BP in supine position during the last 60 seconds before postural change and (ii) BP decrease by subtracting the lowest averaged BP during different time periods (0-15 seconds and 15-180 seconds) after postural change from the supine BP.

Types of OH

Initial $OH_{continuously}$ ($iOH_{continuously}$) was defined as a decrease of at least 40 mm Hg systolic BP and/or 20 mm Hg diastolic BP during the first 15 seconds after standing up compared with supine BP.[17] $OH_{continuously\_15\text{-}180}$ was defined as a decrease of at least 20 mm Hg systolic BP and/or 10 mm Hg diastolic BP after 15 to 180 seconds continuously measured in standing position compared with supine BP. $OH_{continuously}$ was defined as having $iOH_{continuously}$ and/or $OH_{continuously\_15\text{-}180}$. Analyses were performed in 3 types of OH: $OH_{intermittently}$, $OH_{continuously}$, and $iOH_{continuously}$. The $iOH_{continuously}$ group consisted of 49 patients with $iOH_{continuously}$ with or without $OH_{continuously\_15\text{-}180}$ and was compared with patients without any type of $OH_{continuously}$.

Statistical Analyses

Continuous variables with a normal distribution were presented as mean and standard deviation. Values with a skewed distribution (non-Gaussian) were presented as median and interquartile range.

Physical performance tests were categorized into tertiles, except for the standing balance tests, which were analyzed as dichotomous variables. The lowest tertile was defined as the worst performance, the middle tertile as an intermediate performance, and the highest tertile as the best performance. Associations between physical performance and different types of OH were analyzed using binary logistic regression models with adjustments for age, sex, weight, and height.

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS version 22). *P* values below .05 were considered statistically significant. Results were visualized using GraphPad Prism (version 5). For visualization purposes, dynamic physical performance tests and the percentages of geriatric outpatients with $OH_{continuously}$ and $iOH_{continuously}$ per tertile are depicted.

RESULTS

Table 1 shows the characteristics of the geriatric outpatients. $OH_{intermittently}$ was present in 53 patients (19%). In the subgroup, $OH_{continuously}$ was present in 33 patients (57%). In 19 of these 33 patients, both $iOH_{continuously}$ and $OH_{continuously\_15\text{-}180}$ were present. In 5 patients, only $iOH_{continuously}$ was present and in 9 patients, only $OH_{continuously\_15\text{-}180}$.

Association Between Dynamic Physical Performance and Different Types of OH

No association was found between dynamic physical performance and $OH_{intermittently}$, except for patients with an intermediate performance on the CST who had significantly higher odds having $OH_{intermittently}$ compared with patients with the best CST performance (Table 2). Patients with the worst performance on the 4-m Walk Test and on the CST had significantly higher odds having $OH_{continuously}$ and $iOH_{continuously}$ compared with patients with the best performance. In addition, patients with the worst performance on the CST had significantly higher odds having $(i)OH_{continuously}$ compared with patients with intermediate performance. This was also observed for the TUG: patients with an intermediate performance had significantly higher odds having $OH_{continuously}$ compared with those with the

Table 1. Characteristics of Geriatric Outpatients and of the Subgroup With Concurrent Continuously Measured Blood Pressure[a]

Characteristic	N	All (n = 280)	N	Subgroup (n = 58)
Sociodemographics				
Age, mean (SD), y	280	82.2 (7.1)	58	80.6 (7.0)
Female	280	182 (65.0)	58	33 (56.9)
Widowed	275	110 (39.3)	57	17 (29.3)
Living at home	277	228 (82.3)	58	46 (79.3)
Highly educated[b]	275	44 (15.7)	58	10 (17.2)
Health characteristics				
Excessive alcohol use[c]	271	8 (2.9)	58	6 (10.3)
Multimorbidity[d]	266	100 (35.7)	56	19 (32.8)
Body mass index, mean (SD)	265	25.8 (4.4)	57	26.4 (4.9)
Mini-Mental State Examination, median (IQR)	277	27 (24-29)	58	28 (25-29)
Physical performance				
Dynamic				
4-m Walk Test, s, mean (SD)	273	6.4 (3.4)	58	6.8 (4.5)
Chair Stand Test, s, median (IQR)	273	17.5 (12.8-48.8)	57	14.8 (11.6-22.7)
Timed Up and Go, s, median (IQR)	261	17.0 (12.9-24.4)	54	15.3 (12.2-18.2)
Static				
Side-by-side, able to maintain	271	258 (95.2)	58	55 (94.8)
Semitandem, able to maintain	271	220 (81.2)	58	49 (84.5)
Tandem, able to maintain	271	85 (31.4)	58	22 (37.9)
Handgrip strength, kg, mean (SD)	277	25.3 (8.0)	58	27.2 (7.9)
Supine blood pressure[e]				
Systolic, mm Hg, mean (SD)	280	145.2 (24.8)	57	141.7 (24.8)
Diastolic, mm Hg, mean (SD)	280	76.0 (9.9)	57	74.5 (11.0)
Orthostatic hypotension				
$OH_{intermittently}$	280	53 (18.9)	56	7 (12.1)
$OH_{continuously}$	NA	NA	58	33 (56.9)
Only $iOH_{continuously}$	NA	NA	33	5 (15.2)
Only $OH_{continuously\_15\text{-}180}$	NA	NA	33	9 (27.3)
$iOH_{continuously}$ and $OH_{continuously\_15\text{-}180}$	NA	NA	33	19 (57.6)

Abbreviations: iOH, initial orthostatic hypotension; IQR, interquartile range; NA, not applicable; OH, orthostatic hypotension.
[a]Variables are presented as n (%) unless indicated otherwise.
[b]Highly educated is defined as having a university degree.
[c]Excessive alcohol use is defined as more than 14 units per week for females and more than 21 units per week for males.
[d]Multimorbidity is defined as 2 or more diseases of the following: chronic obstructive pulmonary disease, diabetes mellitus, hypertension, malignancy, myocardial infarction, Parkinson's disease, and rheumatoid/(osteo)arthritis.
[e]Intermittently measured for both groups.

best performance and patients with the worst performance had significantly higher odds having $iOH_{continuously}$ compared with those with the best performance. The Figure depicts the percentages of geriatric outpatients with $OH_{continuously}$ and $iOH_{continuously}$ in the tertiles of dynamic physical performance.

Association Between Static Physical Performance and Different Types of OH

No association was found between performance on the standing balance tests (side-by-side, semitandem, and tandem stance) and any type of OH (Table 2). Patients with intermediate handgrip strength had significantly higher odds at having $iOH_{continuously}$ compared with patients with the best handgrip strength.

DISCUSSION

Dynamic physical performance was significantly associated with $OH_{continuously}$ in contrast to static physical performance. This finding is in line with the suggestion that an autonomous hemodynamic response is triggered during the displacement of the CoM caused by the postural change.

Table 2. Physical Performance and Different Types of OH[a]

Physical performance	$OH_{intermittently}$ (n = 280)		$OH_{continuously}$ (n = 58)		$iOH_{continuously}$ (n = 49)	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Dynamic						
4-m WT, s						
Worst vs best	0.9 (0.4-2.1)	.809	7.2 (1.2-44.2)	**.034**[b]	8.0 (1.2-53.3)	**.032**[b]
Worst vs intermediate	0.9 (0.4-2.1)	.885	2.4 (0.5-11.5)	.266	3.4 (0.6-17.6)	.153
Intermediate vs best	1.0 (0.4-2.1)	.912	3.0 (0.6-13.9)	.169	2.4 (0.5-12.5)	.307
CST, s						
Worst vs best	1.8 (0.7-4.5)	.206	12.0 (1.9-75.7)	**.008**[b]	19.6 (2.3-167.1)	**.007**[b]
Worst vs intermediate	0.7 (0.3-1.5)	.316	8.2 (1.4-48.3)	**.021**[b]	15.6 (1.9-129.6)	**.011**[b]
Intermediate vs best	2.7 (1.2-6.1)	**.019**[b]	1.5 (0.3-6.4)	.604	1.3 (0.2-7.0)	.791
TUG, s						
Worst vs best	1.0 (0.4-2.3)	.952	3.5 (0.7-17.0)	.122	8.3 (1.3-55.6)	**.029**[b]
Worst vs intermediate	1.3 (0.6-3.1)	.489	0.4 (0.1-2.0)	.254	2.7 (0.5-16.0)	.268
Intermediate vs best	0.7 (0.3-1.6)	.444	9.3 (1.7-52.2)	**.011**[b]	3.1 (0.6-16.3)	.190
Static						
Standing balance tests, able to maintain						
Side-by-side, able vs unable	1.3 (0.3-6.5)	.732	2.2 (0.1-45.8)	.617	1.4 (0.1-31.6)	.827
Semitandem, able vs unable	0.7 (0.3-1.6)	.396	0.8 (0.1-4.4)	.768	0.5 (0.1-2.9)	.438
Tandem, able vs unable	0.7 (0.3-1.5)	.321	0.4 (0.1-1.3)	.108	0.2 (0.1-1.0)	.057
Handgrip strength, kg						
Worst vs best	3.0 (0.8-10.7)	.101	14.7 (1.0-218.8)	.052	14.1 (0.8-237.3)	.066
Worst vs intermediate	1.0 (0.4-2.4)	.929	1.3 (0.3-6.1)	.751	0.9 (0.2-5.0)	.891
Intermediate vs best	2.8 (1.0-8.1)	.051	11.4 (1.0-134.4)	.052	15.9 (1.0-248.0)	**.048**[b]

Abbreviations: CI, confidence interval; CST, Chair Stand Test; 4-m WT, 4-m Walk Test; iOH, initial orthostatic hypotension; OH, orthostatic hypotension; OR, odds ratio; TUG, Timed Up and Go.
[a]All analyses were adjusted for age, sex, weight, and height.
[b]*P* values in boldface are statistically significant.

This primarily leads to temporary blood volume shifts to the peripheral vasculature, and it could be hypothesized that in patients with OH, the hemodynamic response is inadequate to compensate for the decrease in circulating volume.[18] This consequently leads to a poor physical performance on these dynamic tests and could result in an increased risk of falling. The CST is strongly dependent on physical capacity and endurance of the patient. During the test, it could be speculated that the body's CoM changes repetitively in vertical direction, which could lead to large blood volume shifts and consequently OH in patients with inadequate autonomous regulation. This is the basis for the supposed benefit of nonpharmacological therapy (eg, counter pressure maneuvers and abdominal and lower limb compression) in the management of OH.[19-21]

Studies assessing the association between different types of physical performance (dynamic vs static) and OH are limited. Orthostatic intolerance, defined as the presence of complaints of OH without necessarily having OH, was found to be associated with physical frailty in a community-dwelling population 50 years of age and older. In this study, physical frailty was partly assessed by using a dynamic and static physical performance test (TUG and handgrip strength).[8] However, in this study, no evidence was found that OH on its own is associated with physical frailty after adjustment for confounders, although a trend remained.[8] This conflicting result could be explained by the fact that in this study, OH was measured intermittently and not continuously.

In older patients with Parkinson's disease, standing balance without a postural change (static physical performance), measured by postural sway, was found to be more strongly associated with OH than dynamic physical performance, measured by TUG and 30-m Walk Test,[22] which is in contrast to our findings. This can be explained by differences in measuring BP (intermittently vs continuously), different assessment of standing balance, and disease-specific features of OH in Parkinson's disease, which is characterized by a later occurring and more prolonged BP drop.[23] Orthostatic hypotension in Parkinson's disease is called

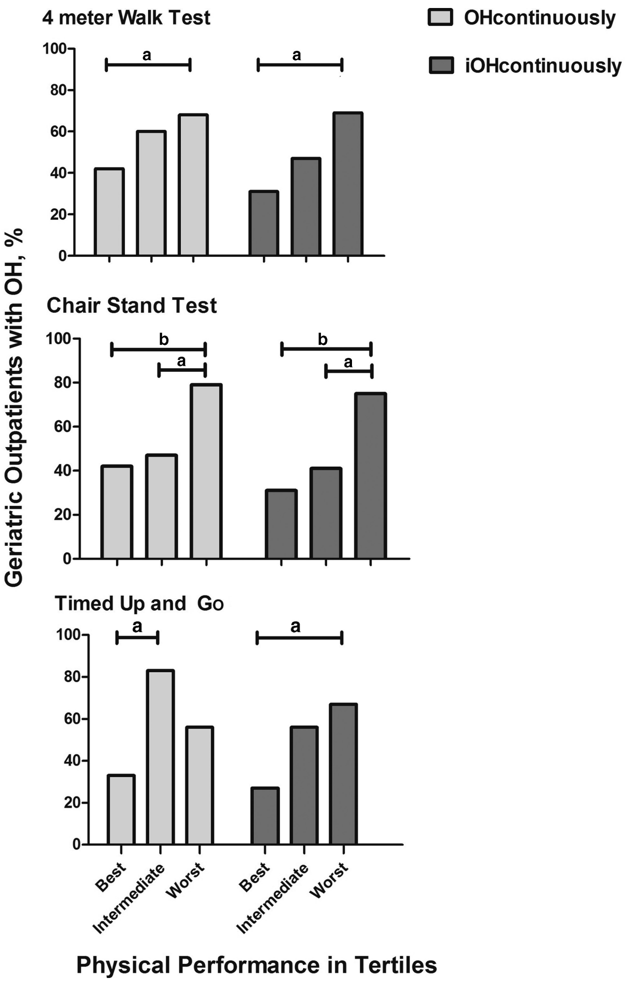

Figure. Dynamic physical performance tests and the percentage of geriatric outpatients with $OH_{continuously}$ and $iOH_{continuously}$. *P* values were obtained by logistic regression analysis. $^{a}P < .05$. $^{b}P < .01$. iOH indicates initial orthostatic hypotension; OH, orthostatic hypotension.

neurogenic orthostatic hypotension and is present in 16% to 58 % of patients.[23] In our study population, only 1.7% of the patients had Parkinson's disease. The pathophysiology of neurogenic orthostatic hypotension is different than the pathophysiology of OH in our study population.[23]

A positive association was previously found between standing balance and OH,[2,22,24] whereas in the present study, this association was absent. These conflicting results could be explained by the type and level of difficulty of the standing balance tests, including more demanding conditions such as closing the eyes during the test[2] and due to a different study population, for example, patients with autonomic dysfunction.[22,24]

The prevalence of OH was much higher measuring BP continuously compared with intermittently. Furthermore, the use of continuously measured BP was more strongly associated between physical performance and OH than the use of intermittently measured BP, even with a smaller number of patients. This emphasizes the additional value of continuously measured BP in the diagnosis of OH. This finding is consistent with previous studies, stating that intermittently measured BP is less accurate in detecting significant BP drops and is especially inadequate to determine iOH.[2,16,17,25] Continuous BP monitors are not yet readily available in daily clinical practice due to the high costs and applicability. However, there is evidence that continuous BP monitors outperform intermittent BP assessment by standard sphygmomanometers in diagnosing OH and iOH.[2]

The strength of this study is the well-defined cohort, providing a clinically relevant study population of geriatric outpatients. Limitations of the study are the cross-sectional design, ruling out the possibility of describing causal relations, and the smaller sample size of the subgroup.

CONCLUSION

Diminished dynamic physical performance with a substantial postural change with subsequent CoM displacement is associated with OH in geriatric outpatients, indicating the clinical importance of BP regulation during physical performance in daily life. Further assessment of individuals at risk and evaluation of successful strategies to counteract the detrimental effects of OH require continuous blood pressure measurements during postural change and movement.

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