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Orthostatic Blood Pressure Recovery Measured Using a Sphygmomanometer Is Not Associated with Physical Performance or Number of Falls in Geriatric Outpatients

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Orthostatic hypotension · Chair stand test · Sphygmomanometer

Abstract
Background: Orthostatic hypotension (OH) and impaired OH recovery derived from beat-to-beat blood pressure (BP) measurements are associated with detrimental clinical outcome, but the clinical relevance of OH recovery assessed using the widely available sphygmomanometer is still unclear. ***Method:*** 635 geriatric outpatients underwent comprehensive geriatric assessment, including orthostatic BP measurements using a sphygmomanometer, during supine rest and 1 and 3 min after standing up and assessment of physical performance (i.e., the timed up and go test and the Short Physical Performance Battery) and the number of falls in the past year. The association between BP recovery, defined as BP at 3 min minus BP at 1 min after standing up, with physical performance and falls was assessed using regression analyses, adjusting for age and sex, both in the entire cohort and after stratifying for the presence of OH at 1 min after standing up. ***Results:*** BP recovery was not associated with physical performance or number of falls, neither in the entire cohort, nor in subpopulations with or without OH. ***Conclusion:*** The clinical relevance of BP recovery between 1 and 3 min after standing up could not be demonstrated. The results suggest that sphygmomanometer measurements have an inadequate time resolution to record the clinically relevant dynamics of orthostatic BP recovery.

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Introduction

Orthostatic hypotension (OH) is a systolic/diastolic blood pressure (SBP/DBP) of >20/10 mm Hg within 3 min after standing up [1]. OH may be accompanied by symptoms of dizziness, fainting, and falls and is associated with impaired physical and cognitive functioning, falls, morbidity, and mortality [2–7]. Impaired recovery

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from OH may lead to detrimental clinical outcome by prolonged brain hypoperfusion [2].

Previous studies used a number of different BP recovery measures derived from continuous (beat-to-beat) BP measurements during and after standing up and found a lower BP recovery to be associated with physical performance, frailty, falls, and cognitive decline [8–11] but not with mortality [12–14]. However, continuous BP measurements are most often not available in clinical practice, in contrast to intermittent (sphygmomanometer) BP measurements. Studies on the relationship between timing of intermittent orthostatic BP measurements and clinical outcome are contradictory [15, 16], and no studies have addressed the association between intermittently assessed BP recovery and clinical outcome. Intermittently measured BP recovery between 1 and 3 min after standing up may reflect the effectiveness of the baroreflex, arterial and venous vasoconstriction, and cardiac contractility [9].

This study assessed the association between orthostatic BP recovery between 1 and 3 min measured using a sphygmomanometer and physical performance and falls in geriatric outpatients. We hypothesized that a higher BP recovery is associated with better physical performance and a lower incidence of falls.

Methods

Study Population and Design

Patients referred to the geriatric outpatient clinic of Bronovo hospital (The Hague, The Netherlands; March 2011 to January 2012; $N = 257$) and the Center of Geriatrics Amsterdam (Amsterdam UMC, The Netherlands; January 2014 to December 2015; $N = 378$) undergoing a comprehensive geriatric assessment were included in this study.

Data Collection

Information about age, sex, height, weight, living situation, and smoking habits were extracted from medical records. BP measurements were performed in all patients in the supine position (baseline) and after 1 and 3 min standing up using a sphygmomanometer. Patients measured in the Bronovo hospital were supported with an automatic lift chair (Vario 570; Fitform B.V., Best, The Netherlands) during standing up.

Physical performance was assessed according to the timed up and go test (TUG) and Short Physical Performance Battery (SPPB). The TUG measures the time needed to stand up from a chair without using the hands, walk around a cone, and be seated again [17]. The SPPB tests the capacity to maintain balance during 10 s of side-by-side stance, semi-tandem stance and tandem stance, preferred walking speed on a 4-m trajectory, and the time needed to complete the chair stand test (CST) [18]. The CST measures the time needed to stand up from a chair and sit down for 5 times as quickly as possible [18]. The number of falls was assessed using a questionnaire asking for the number of falls in the past year. All measurements and the questionnaire were performed during the same visit as part of the comprehensive geriatric assessment, in the following order: falls questionnaire, orthostatic BP, CST, walking speed, and TUG measurements.

Data Analysis

All analyses were performed using IBM SPSS Statistics, version 25. Data are presented using mean and standard deviation in case of normal distribution and using median and interquartile range (IQR) otherwise.

OH was defined as a systolic drop of at least 20 mm Hg and/or a diastolic drop of at least 10 mm Hg BP relative to baseline at either 1 or 3 min after standing up. BP recovery was defined as BP measured at 3 min after standing up minus BP measured at 1 min after standing up.

Prior to regression analysis, log transformations were applied to the CST and TUG times to obtain normal distributions. SPPB total score and number of falls were dichotomized at their median value. SPPB total score was also divided into categories: disabled (score 0–2), frail (score 3–9), and nonfrail (score 10–12).

The association between BP recovery and TUG, 4mWS, and CST was assessed using linear regression, adjusting for age and sex. The association between BP recovery and SPPB total score and number of falls was assessed using logistic regression, adjusting for age and sex. Linear regression models could not be used in this analysis because of the nonnormal distribution of the number of falls. All analyses were performed both in the entire group of patients and after stratifying for the presence of OH at 1 min after standing up. Statistical significance was set at 0.05 and Bonferroni corrected for multiple (ten) comparisons.

Results

Orthostatic BP, physical performance, and falls data were available for 635 geriatric patients. The patient characteristics are presented in Table 1. The mean age of patients was 81.1 (standard deviation 6.9) years. 41.1% of the patients were men and 52.4% were living independently. Median baseline SBP and DBP were 144 (IQR 132–163) mm Hg and 79 (IQR 72–87) mm Hg, respectively. 179/635 (28.2%) patients had OH. Median SBP and DBP recovery was 4.0 (IQR −3.0 to 12.0) mm Hg and 2.0 (IQR −2.0 to 5.0) mm Hg, respectively.

Table 2 presents the results from the regression analyses on the associations between BP recovery and physical performance and falls. After correction for multiple comparisons, BP recovery was neither associated with physical performance nor number of falls in the entire populations or in the subpopulations with or without OH.

Online suppl. Supplementary Table 1 (see www.karger.com/doi/10.1159/000515658 for all online suppl. material) lists the results from logistic regression analyses on the associations between BP recovery and SPPB total score categories. No significant associations were found after correction for multiple comparisons.

Table 1. Patient characteristics

Characteristic	*N*	COGA (*N* = 378)	*N*	Bronovo (*N* = 257)	*N*	All (*N* = 635)
Sociodemographics						
Age, mean (SD), years	378	80.5 (6.6)	257	82.0 (7.2)	635	81.1 (6.9)
Male, *n* (%)	378	165 (43.7)	257	96 (37.4)	635	261 (41.1)
Living independently, *n* (%)	360	186 (49.2)	246	147 (57.2)	606	333 (52.4)
Health characteristics						
Currently smoking, *n* (%)	350	28 (7.4)	119	22 (8.6)	469	50 (7.9)
Supine resting BP						
SBP, median [IQR], mm Hg	378	146 [134–165]	257	142 [130–157]	635	144 [132–163]
DBP, median [IQR], mm Hg	378	81 [74–90]	257	76.0 [69–83]	635	79 [72–87]
OH and BP recovery between 1 and 3 min after standing up						
OH,[1] *n* (%)	378	138 (36.5)	257	41 (16.0)	635	179 (28.2)
SBP recovery, median [IQR], mm Hg	378	5.0 [−2.0 to 14.0]	257	2.0 [−3.0 to 9.0]	635	4.0 [−3.0 to 12.0]
DBP recovery, median [IQR], mm Hg	378	2.0 [−2.0 to 6.0]	257	1.0 [−2.0 to 4.0]	635	2.0 [−2.0 to 5.0]
Physical performance and falls						
TUG, median [IQR], s	265	15.0 [12.0–18.5]	232	16.6 [12.6–23.0]	497	15.7 [12.1–20.4]
Walking speed, mean (SD)/median [IQR], m/s	314	0.86 (0.42)	248	0.74 [0.55–0.91]	562	0.81 (0.36)
CST, median [IQR], s	304	13.9 [11.6–18.8]	217	15.1 [12.3–20.3]	521	14.3 [11.7–19.4]
SPPB total score, median [IQR], points	360	8.0 [6.0–10.0]	249	7.0 [5.0–10.0]	609	8.0 [5.0–10.0]
SPPB total score 0–2, *n* (%)	360	19 (5.2)	249	18 (7.2)	609	37 (6.1)
SPPB total score 3–9, *n* (%)	360	216 (60.0)	249	165 (66.3)	609	381 (62.6)
SPPB total score 10–12, *n* (%)	360	125 (34.7)	249	66 (26.5)	609	191 (31.4)
Number of falls, median [IQR], counts	180	2.0 [1.0–4.0]	157	2.0 [1.0–4.0]	337	2.0 [1.0–4.0]

OH, orthostatic hypotension; SD, standard deviation; IQR, interquartile range; SBP, systolic blood pressure; DBP, diastolic blood pressure; CST, chair stand test; SPPB, Short Physical Performance Battery; TUG, timed up and go test; COGA, Center of Geriatrics Amsterdam. [1] Number and proportion of patients with OH, defined as a SBP/DBP drop of 20/10 mm Hg at 1 and/or 3 min after standing up.

Discussion

BP recovery between 1 and 3 min after standing up measured with a sphygmomanometer was not associated with physical performance or number of falls in a large population of geriatric outpatients. The present results point in a different direction than previous studies, which used continuous BP measurements and reported BP recovery between 30 and 60 s after standing up to be associated with impaired physical performance, frailty, and falls [9, 11]. Patients may be particularly vulnerable for inadequate BP recovery in this time window as cerebral autoregulation might not have reached its full capacity [19]. Sphygmomanometer BP measurements miss this clinically relevant time window due to their low time resolution. The finding that stratification for the presence of OH at 1 min after standing up did not change the results may also be attributed to the fact that the largest BP drop typically occurs within 1 min and is therefore missed by sphygmomanometer measurements [8]. Timing of BP readings at exactly 1 and 3 min is difficult using a sphygmomanometer due to the required cuff inflation, deflation, and auscultation, potentially resulting in substantial errors. Sphygmomanometer BP measurements do not allow for averaging of BP values within short time intervals (e.g., 5–10 s), which could cancel out random BP fluctuations [9]. These limitations of sphygmomanometer orthostatic BP measurements may explain the different findings between the present study and aforementioned studies. Although physical performance was measured objectively, self-reported falls may be subject to recall bias, which is a limitation of this study.

Conclusions, Implications, and Further Directions

BP recovery between 1 and 3 min after standing up measured with a sphygmomanometer was not associated with physical performance or number of falls in geriatric

Table 2. BP recovery and physical performance and falls

	TUG, s[a] (*n* = 497)	Walking speed, m/s (*n* = 562)	CST, s[a] (*n* = 521)	SPPB total score, points (*n* = 609)	Number of falls, counts (*n* = 337)
Entire population					
SBP recovery					
N	497	562	521	609	337
β/OR	–0.001 (β)	0.000 (β)	0.001 (β)	0.988 (OR)	0.992 (OR)
95% CI	–0.004 to 0.002	–0.002 to 0.002	–0.002 to 0.003	0.977–1.000	0.975–1.010
p value	0.409	0.833	0.689	0.055	0.377
DBP recovery					
N	497	562	521	609	337
β/OR	–0.002 (β)	0.002 (β)	0.001 (β)	0.993 (OR)	0.985 (OR)
95% CI	–0.006 to 0.002	–0.001 to 0.005	–0.003 to 0.006	0.976–1.010	0.962–1.008
p value	0.344	0.233	0.540	0.404	0.199
Patients with OH					
SBP recovery					
N	96	123	103	131	79
β/OR	–0.001 (β)	0.002 (β)	0.000 (β)	0.987 (OR)	0.986 (OR)
95% CI	–0.005 to 0.004	–0.001 to 0.005	–0.004 to 0.005	0.966–1.008	0.951–1.022
p value	0.805	0.274	0.836	0.225	0.447
DBP recovery					
N	96	123	103	131	79
β/OR	–0.008 (β)	0.008 (β)	–0.005 (β)	1.011 (OR)	0.963 (OR)
95% CI	–0.016 to 0.000	0.002–0.013	–0.013 to 0.004	0.974–1.048	0.913–1.016
p value	0.061	0.005	0.258	0.572	0.167
Patients without OH					
SBP recovery					
N	401	439	418	478	258
β/OR	–0.002 (β)	–0.001 (β)	0.001 (β)	0.988 (OR)	0.992 (OR)
95% CI	–0.005 to 0.002	–0.004 to 0.001	–0.003 to 0.005	0.972–1.004	0.971–1.014
p value	0.371	0.327	0.502	0.127	0.473
DBP recovery					
N	401	439	418	478	258
β/OR	0.000 (β)	0.000 (β)	0.004 (β)	0.987 (OR)	0.990 (OR)
95% CI	–0.005 to 0.005	–0.004 to 0.004	–0.002 to 0.009	0.967–1.007	0.964–1.016
p value	0.878	0.957	0.174	0.198	0.454

The table lists the results from the linear regression analyses with BP recovery as the independent variable, physical performance or falls as the dependent variable, and age and sex as covariates. SBP, systolic blood pressure; DBP, diastolic blood pressure; β, regression coefficient; OR, odds ratio; CI, confidence interval; TUG, timed up and go test; CST, chair stand test; SPPB, Short Physical Performance Battery. [a] log-transformed.

outpatients. Orthostatic BP measurements using a sphygmomanometer have an inadequate time resolution to record the clinically relevant dynamics of orthostatic BP recovery. The results suggest that continuous BP measurements should be made routinely available and used in geriatric outpatient clinics to record clinically relevant dynamics of BP recovery. The results further suggest that the use of sphygmomanometer BP measurements should be avoided, despite their better availability. Further studies should point out whether continuously measured orthostatic BP recovery has potential to predict physical performance trajectories and falls. These studies should measure orthostatic BP recovery simultaneously using continuous BP measurement and a sphygmomanometer in the same population to better enable comparison of the clinical value of both techniques.

Statement of Ethics

The study was performed in accordance with the Declaration of Helsinki and approved by the local medical Ethics Committee of the VU University Medical Center Amsterdam (Center of Geriatrics Amsterdam cohort; ref. No. 2017.582) and the Institutional Review Board of the Leiden University Medical Center (ref. No. LUMC2010.x; Bronovo cohort), and patients gave written consent to participate in the study.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

Study concept and design: A. Mol, M.E.C. Blom, D.J. van den Bosch, C.G.M. Meskers, and A.B. Maier. Acquisition of data: M.E.C. Blom and D.J. van den Bosch. Analysis and interpretation of data: A. Mol, M.E.C. Blom, and D.J. van den Bosch. Drafting of the manuscript: A. Mol, M.E.C. Blom, and D.J. van den Bosch. Critical revision of the manuscript for important intellectual content: R.J.A. Van Wezel, C.G.M. Meskers, and A.B. Maier.

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