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Initial impact of the COVID-19 pandemic on physical activity and sedentary behavior in hypertensive older adults: An accelerometer-based analysis

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ABSTRACT

Background: This study reports the accelerometer-based physical activity (PA) and sedentary behavior (SB) before and during the COVID-19 pandemic in hypertensive older adults.
Methods: Thirty-five hypertensive older adults were included in this observational study. Accelerometer-based PA and SB measures were assessed before (January to March 2020) and during (June 2020) the COVID-19 pandemic. Linear mixed models were used to assess within-group changes in PA and SB measures, adjusted by accelerometer wear time.
Results: Before COVID-19 pandemic participants presented: 5809 steps/day (SE = 366), 303.1 min/day (SE = 11.9) of light PA, 15.5 min/day (SE = 2.2) of moderate-vigorous PA, and 653.0 min/day (SE = 12.6) of SB. During COVID-19 pandemic there was a decrease in steps/day ($\beta = -886$ steps/day, SE = 361, $p = 0.018$), in moderate-vigorous PA ($\beta = -2.8$ min/day, SE = 2.4, $p = 0.018$), and a trend in light PA ($\beta = -26.6$ min/day, SE = 13.4, $p = 0.053$). In addition, SB increased during the COVID-19 pandemic ($\beta = 29.6$ min/day, SE = 13.4, $p = 0.032$). The magnitude of changes was greater on the weekend, mainly for steps/day ($\beta = -1739$ steps/day, SE = 424, $p < 0.001$) and the SB pattern (more time spent in bouts of ≥10 and 30 min, less breaks/day and breaks/h).
Conclusions: The COVID-19 pandemic may elicit unhealthy changes in movement behavior in hypertensive older adults. Lower PA, higher and more prolonged SB on the weekend are the main features of the behavioral changes.

1. Introduction

The coronavirus disease (COVID-19) pandemic has completed nine months since the outbreak in Wuhan, China. To date, it has infected almost 33 million individuals and caused more than 991 thousand deaths across the globe (World Health Organization, 2020). Older age and cardiovascular risk factors such as hypertension and diabetes are associated with an increased risk of infection and severity of COVID-19 (Espinosa et al., 2020; Yang et al., 2020). Comprehensive social distancing policies, which include closing schools, prohibiting agglomerations, travelling restrictions, and staying-at-home recommendations, have been adopted by several countries to prevent introducing the disease to new areas or reduce human-to-human transmission in areas where COVID-19 is already circulating (Aquino et al., 2020). Despite the benefits of social distancing as a public health strategy during the COVID-19 pandemic, its consequences on daily lifestyle have negatively impacted the cardiovascular (Mattioli et al., 2020) and mental health of individuals (Dubey et al., 2020).

Although changes in physical activity (PA) and sedentary behavior (SB) are expected (Hall et al., 2020), the impact of COVID-19 pandemic on objectively measured PA and SB is still unclear. For older adults with hypertension who represent a high-risk group (Espinosa et al., 2020; Yang et al., 2020), the description of movement behavior during the COVID-19 pandemic may play a pivotal role for better understanding their health-related consequences and guide feasible future preventive and therapeutic actions. Herein, we report the accelerometer-based PA and SB measures before and during the COVID-19 pandemic in hypertensive older adults involved in an interrupted clinical trial.

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2. Materials and methods

2.1. Participants and study design

This observational study was approved by the Research Ethics Board at the Onofre Lopes University Hospital (protocol 4.005.835/2020). The study was conducted according to the Declaration of Helsinki. The participants were informed about all study procedures and provided written informed consent. A sample of Brazilian hypertensive older adults who were screened for the Hypertension EXercise Approaches study (HEXA study; for more details: http://ensaiosclinicos.gov.br/rg/RBR-4ntszb/) were assessed before and during a period of social distancing policy imposed due to the COVID-19 pandemic. This study was conducted in the city of Natal, the capital city of the state of Rio Grande do Norte, Brazil. A total of 41 participants were screened for the HEXA study before the social distancing period (from January 24th to March 15th, 2020), including accelerometer-based PA and SB measures. The HEXA study was interrupted immediately after the first case of COVID-19 in the city of Natal on March 12th, 2020, following the recommendations of the state authorities and the Federal University of Rio Grande do Norte. All participants have been receiving weekly phone calls from the research staff since March 17th to be monitored regarding COVID-19 symptoms. The participants were invited by phone calls to participate in the present study after a 10-week period from the first case of COVID-19 in the city of Natal. All participants who agreed to participate in this study received sterilized accelerometers in their homes between June 1st and June 3rd, 2020, to be used during a one-week period. When the HEXA study was interrupted on March 17th, the national epidemiological bulletin reported 291 cases and one death by COVID-19 in Brazil, and one case in the city of Natal (0 deaths) (Brazil. Ministry of Health, 2020; Laboratory of Technological Innovation in Health, 2020). On June 1st, the first day of the accelerometer-based PA and SB measures, the national epidemiological bulletin reported 526,447 cases in Brazil (29,937 deaths) and 3103 cases in the city of Natal (105 deaths) (Brazil. Ministry of Health, 2020; Laboratory of Technological Innovation in Health, 2020). On June 4th, the governor of the state of Rio Grande do Norte implemented a more rigid social distancing policy, especially for older adults and high-risk individuals. Therefore, the accelerometer-based PA and SB measures occurred during a period of high mobility restriction in the public areas within the city of Natal and with a clear 'stay-at-home' message for population.

2.2. Physical activity and sedentary behavior measures

Accelerometer-based PA and SB measures were assessed by the Actigraph GT3X (Actigraph LLC, Pensacola, USA). Participants wore a hip accelerometer during seven consecutive days, including awake and asleep periods. They also filled out a diary describing the time they took off the accelerometer during the awake period, went to bed to sleep and wake up. A sampling rate of 60 Hz with epoch of 60 s was used. Non-wearing time was defined as ≥90 consecutive minutes of zero counts with a tolerance of up to 2 min of ≥100 cpm (Choi et al., 2011). Participants with at least three valid days of accelerometer wear time (≥600 min/day) with at least one weekend day were included in the data analysis (Trost et al., 2005). The cut-offs to define SB, light PA, and moderate-vigorous PA were: 0–99 cpm, 100–1951 cpm, ≥1952 cpm, respectively (Freedson et al., 1998; Matthews et al., 2008). Accelerometer-based PA and SB measures were analyzed as total period (weighted average; weekdays and weekend), weekdays and weekend using the ActiLife version 6.13.3.2 software program. The following variables were considered for data analysis: steps/day; time spent in SB, light PA, and moderate-vigorous PA (min/day and accelerometer wear time %); bouts ≥10 and 30 consecutive minutes of SB, light PA, moderate-vigorous PA (min/day and bouts/day); length of sedentary bouts (min/day; defined as time spent in SB ÷ number of sedentary bouts ≥1 min); sedentary breaks of ≥1 and ≥5 min (breaks/day; defined as ≥100 cpm following a sedentary bout); break rate (breaks/h; defined as number of breaks ÷ accelerometer wear time) (Boerema et al., 2020).

2.3. Statistical analysis

Descriptive data are presented as mean ± standard deviation, absolute and relative frequencies. Linear mixed models with subject as a random effect and time and covariates as fixed effects were used to assess within-group changes in accelerometer-based PA and SB measures, controlling for the following covariates: a) only by accelerometer wear time; b) age, sex and accelerometer wear time. The subject was included as a random effect due to the high intra-subject variability, as observed by the intra-subject intraclass correlation coefficient (ICC) between 0.26 and 0.64 for volume-related variables of SB and PA and by the intra-subject ICC between 0.08 and 0.73 for pattern-related variables of SB and PA, respectively. Maximum likelihood estimation was used to calculate the coefficient estimates (β), estimated marginal means (EMM), standard error (SE), and 95% confidence interval (CI). Residuals distribution was verified using the normal Q-Q plot. The variables that were not normally distributed were square root transformed. In these cases, the model analysis was performed only with the transformed variables, but the original descriptive results were presented for a better clinical interpretation. A two-tailed $p < 0.05$ was considered statistically significant for all analyses. Statistical analyses were performed using IBM SPSS Statistics for Win/v.25.0 (IBM Corp., Armonk, NY).

3. Results

3.1. Sample characteristics

Five participants declined to participate in the study (three for personal reasons, one was sick with dizziness symptoms, and one was in quarantine due to direct contact with a relative infected by COVID-19). One participant was excluded due to a technical issue with the accelerometer. Thus, a total of 35 participants were included in the final analysis. Table 1 shows the characteristics of the included participants.

Table 1
Characteristics of the participants (n = 35).

	Mean ± SD or n (%)
Age, yrs	65.6 ± 3.8
Females, n (%)	23 (65.7)
Married, n (%)	17 (48.6)
Living alone, n (%)	5 (14.3)
Post-secondary education, n (%)	10 (28.6)
Body mass index, kg/m^2	27.3 ± 3.4
Resting SBP, mmHg	134.3 ± 18.3
Resting DBP, mmHg	74.1 ± 9.4
Resting HR, bpm	71.1 ± 12.0
Hypertension diagnosis, yrs	12.1 ± 9.1
Risk factors, n (%)	
Diabetes	12 (34.3)
Dyslipidemia	18 (51.4)
Overweight	12 (34.3)
Obesity	5 (14.3)
Ex-smoker	8 (22.9)
Medication, n (%)	
ACE inhibitor	5 (14.3)
Angiotensin-receptor antagonists	26 (74.3)
Calcium-channel blocker	7 (20.0)
Diuretics	12 (34.3)
Beta-blockers	9 (25.7)
Statins	13 (37.1)
Hypoglycemics	14 (40.0)
Anxiolytic/antidepressant	10 (28.6)

Values are expressed as mean ± standard deviation (SD) or absolute (n) and relative frequencies (%).
Abbreviations: ACE, angiotensin converting enzyme; DBP, diastolic blood pressure; HR, heart rate; SBP, systolic blood pressure.

Most participants were women (65.7%) and married (48.6%). All participants were taking antihypertensive medication(s). In addition, most participants had dyslipidemia (51.4%) and were overweight/obese (48.6%). Approximately one-third had type 2 diabetes (34.3%) and one-fourth were ex-smokers (22.9%).

All participants had 6–7 valid days of accelerometer use before and during the COVID-19 pandemic. Accelerometer wear time before and during the COVID-19 pandemic were: total period (weighted average), 997.7 ± 71.1 vs. 945.7 ± 71.2 min/day ($p = 0.003$); weekdays, 1011.6 ± 79.3 vs. 953.3 ± 77.4 min/day ($p = 0.002$); weekend, 963.0 ± 117.8 vs. 927.3 ± 78.2 min/day ($p = 0.134$).

3.2. Volume of physical and sedentary behavior

The PA and SB volumes before and during the COVID-19 pandemic are shown in Table 2 and Fig. 1. Considering the total period (weekdays and weekend), there was a significant increase in SB (β = 29.6 min/day, $p = 0.032$), a decrease in steps/day (β = −886, $p = 0.018$), moderate-vigorous PA (β = −2.8 min/day, $p = 0.018$), and a trend for light PA (β = −26.6 min/day, $p = 0.053$). Similar results were observed in the models using the accelerometer wear time %. There was a significant decrease in moderate-vigorous PA (β = −2.3 min/day, $p = 0.030$) and a decreasing trend for steps/day (β = −721, $p = 0.081$) on weekdays. No significant changes were observed for SB and light PA. However, there was a significant increase in SB and a decrease in light PA and moderate-vigorous PA in the models using the accelerometer wear time %. Greater changes in movement behavior were observed on the weekend. There was a significant increase in SB (β = 57.8 min/day, $p < 0.001$) and a decrease in light PA (β = −51.6 min/day, $p = 0.003$) and moderate-vigorous PA (β = −5.8 min/day, $p = 0.003$) in both models (min/day and accelerometer wear time %). There was also a significant decrease in steps/day on the weekend (β = −1739, $p < 0.001$). In addition, it was tested the within-group changes in PA and SB volumes controlling for age and sex (Supplementary Table 1). After the inclusion of these covariates, the results remained unchanged.

3.3. Pattern of physical and sedentary behavior

The PA and SB patterns before and during the COVID-19 pandemic are shown in Table 3. Considering the total period, there was a significant increase in sedentary bouts ≥10 and 30 min (β = 42.0 min/day; β = 37.7 min/day, respectively; $p < 0.05$) and the length of sedentary bouts. Also, there was a decrease in the number of breaks ≥1 and 5 min from SB (β = −6.0 breaks/day; β = −2.3 breaks/day, respectively; $p < 0.05$) and the break rate. There was a significant increase in sedentary bouts ≥30 min (β = 33.4 min/day, $p = 0.023$) and the length of sedentary bouts, as well as a decrease in the break rate on weekdays. The greater changes in the SB pattern were observed on the weekend. There was a significant increase in sedentary bouts ≥10 and 30 min (β = 73.9 min/day; β = 54.4 min/day, respectively; $p < 0.05$) and the length of sedentary bouts. In addition, there was a decrease in the number of breaks ≥1 and 5 min from SB (β = −8.0 breaks/day; β = −4.6 breaks/day, respectively; $p < 0.05$) and the break rate. No significant changes were observed in the PA pattern on weekdays or on the weekend. In addition, it was tested the within-group changes in PA and SB patterns controlling for age and sex (Supplementary Table 2). After the inclusion of these covariates, the results remained unchanged.

4. Discussion

This study aimed to report the objectively measured movement behavior of hypertensive older adults before and during the COVID-19 pandemic. The main findings showed that the individuals increased the time spent in SB, decreased the amount of steps/day and the time spent in light and moderate-vigorous PA during the COVID-19 pandemic. In addition, the SB pattern was modified, whereas

Table 2
Volume of physical and sedentary behavior before and during the COVID-19 pandemic in hypertensive older adults (n = 35).

	Before EMM (95% CI)	During EMM (95% CI)	β[a]	SE	95% CI	p-Value
Sedentary behavior						
Average						
Sedentary time, min/day	653.0 (627.7, 678.3)	682.6 (657.3, 707.9)	29.6	13.4	2.6, 56.5	**0.0321**
Sedentary, wear time %	66.8 (64.2, 69.4)	70.9 (68.3, 73.6)	4.1	1.2	1.7, 6.5	**0.0013**
Weekdays						
Sedentary time, min/day	665.7 (640.5, 691.0)	687.6 (662.3, 712.8)	21.8	13.6	−5.6, 49.2	0.1156
Sedentary, wear time %	67.4 (64.8, 69.9)	70.7 (68.1, 73.2)	3.3	1.2	0.8, 5.8	**0.0106**
Weekend						
Sedentary time, min/day	616.8 (586.6, 647.1)	674.6 (644.3, 704.8)	57.8	15.9	25.6, 89.9	**0.0009**
Sedentary, wear time %	65.4 (62.2, 68.6)	71.7 (68.4, 74.9)	6.3	1.6	3.0, 9.5	**0.0004**
Physical activity						
Average						
Steps/day	5809 (5075, 6543)	4922 (4188, 5656)	−886	361	−1612, −161	**0.0177**
Light PA, min/day	303.1 (279.3, 326.9)	276.5 (252.7, 300.4)	−26.6	13.4	−53.6, 0.4	0.0531
Light PA, wear time %	31.6 (29.1, 34.0)	27.8 (25.4, 30.3)	−3.7	1.2	−6.1, −1.3	**0.0038**
MVPA, min/day	15.5 (10.5, 20.5)	12.7 (7.7, 17.7)	−2.8	2.4	−7.6, 2.0	–
Sqrt MVPA, min/day	3.6 (3.0, 4.2)	2.8 (2.2, 3.5)	−0.8	0.3	−1.4, −0.1	**0.0181**
MVPA, wear time %	1.6 (1.1, 2.1)	1.2 (0.7, 1.7)	−0.4	0.2	−0.9, 0.0	**–**
Sqrt MVPA, wear time %	1.2 (1.0, 1.4)	0.9 (0.7, 1.1)	−0.3	0.1	−0.5, −0.1	**0.0015**
Weekdays						
Steps/day	5887 (5113, 6660)	5165 (4391, 5939)	−721	406	−1538, 95	0.0819
Light PA, min/day	300.6 (276.7, 324.5)	280.8 (256.9, 304.6)	−19.8	13.5	−46.9, 7.3	0.1480
Light PA, wear time %	31.0 (28.6, 33.4)	28.0 (25.6, 30.4)	−3.0	1.2	−5.5, −0.5	**0.0197**
MVPA, min/day	16.2 (10.9, 21.5)	13.9 (8.6, 19.2)	−2.3	2.8	−7.9, 3.2	–
Sqrt MVPA, min/day	3.7 (3.1, 4.4)	3.0 (2.3, 3.6)	−0.8	0.3	−1.5, −0.1	**0.0301**
MVPA, wear time %	1.7 (1.2, 2.2)	1.4 (0.8, 1.9)	−0.3	0.2	−0.8, 0.2	–
Sqrt MVPA, wear time %	1.2 (1.0, 1.4)	0.9 (0.7, 1.1)	−0.3	0.1	−0.5, −0.1	**0.0062**
Weekend						
Steps/day			−1739	424		**0.0002**

(*continued on next page*)

Table 2 (*continued*)

	Before EMM (95% CI)	During EMM (95% CI)	β[a]	SE	95% CI	*p*-Value
	5839 (5046, 6632)	4100 (3307, 4893)			−2599, −879	
Light PA, min/day	313.7 (285.0, 342.4)	262.1 (233.4, 290.8)	−51.6	15.9	−83.9, −19.2	**0.0026**
Light PA, wear time %	33.1 (30.1, 36.2)	27.5 (24.4, 30.5)	−5.6	1.6	−8.9, −2.3	**0.0014**
MVPA, min/day	14.5 (9.6, 19.4)	8.6 (3.8, 13.5)	−5.8	2.1	−10.2, −1.5	–
Sqrt MVPA, min/day	3.2 (2.5, 3.9)	2.1 (1.5, 2.8)	−1.1	0.3	−1.8, −0.4	**0.0030**
MVPA, wear time %	1.6 (1.0, 2.1)	0.9 (0.4, 1.4)	−0.7	0.2	−1.1, −0.2	–
Sqrt MVPA, wear time %	1.1 (0.9, 1.3)	0.7 (0.5, 0.9)	−0.4	0.1	−0.6, −0.2	**0.0015**

Values are expressed as estimated marginal means (EMM), coefficient estimates (β), standard error (SE), and 95% confidence interval (CI).
Bold values indicate significance at $p < 0.05$.
Abbreviations: PA, physical activity; MVPA, moderate to vigorous physical activity; Sqrt, square root.
[a] Model adjusted for accelerometer wear time, except for the models of measures of wear time %.

prolonged/uninterrupted sedentary time increased and breaks in SB decreased. Importantly, the greater changes in PA and SB occurred on the weekend.

A comprehensive social distancing policy has been adopted during the COVID-19 pandemic worldwide, including high-, middle- and low-income countries (Aquino et al., 2020). Particularly in middle- and low-income countries where individuals often live in houses with limited space shared with other family members (Organisation for Economic Co-operation and Development, 2020), it seems reasonable to expect that a period of high mobility restriction in the public areas and a 'stay-at-home' recommendation might impact the PA and SB levels (Hall et al., 2020). Indeed, our findings confirm the expected unhealthy changes in movement behavior during the COVID-19 pandemic. We highlight that the decreases in PA and the increases in SB levels occurred in a sample of hypertensive older adults who already had low PA (~5800 steps/day, ~5 h/day of light PA, and ~ 15 min/day of moderate-vigorous PA) and high SB (~11 h/day) levels before the COVID-19 pandemic.

Hypertensive older adults are a high-risk group for COVID-19 severity (Espinosa et al., 2020; Yang et al., 2020). Since the interruption of the HEXA study in March 2020, the participants have been asked about COVID-19 symptoms and their compliance with the social distancing policy by weekly phone calls. From March 2020 to the end of the data collection on June 2020, no participants reported COVID-19 symptoms and all of them reported that they are following the social distancing policy imposed in the city of Natal, which included staying at home. Interestingly, the greater changes in PA and SB were observed on the weekend, which may be partially explained by higher restrictions for activities commonly performed on Saturday and Sunday outside home, such as playing with grandchildren, going to a park, attending religious activities, and shopping at malls and grocery stores. Our findings suggest that there was a reallocation of time spent in light PA and steps for time spent in SB with a more prolonged/uninterrupted pattern especially on the weekend.

A high amount of time spent in SB, especially in a prolonged/uninterrupted sitting pattern, might have several cardiovascular- and metabolic-related implications (Biswas et al., 2015). Although it is not possible to determine how much time the participants spent sitting in the present study, this is the most common SB in humans. Prolonged/uninterrupted sitting reduces the blood flow of the lower limbs, decreasing the shear stress, which attenuates nitric oxide and increases endothelin 1 production, in turn promoting endothelial dysfunction due to a decreased flow-mediated dilation (Carter et al., 2017). These alterations can contribute to increase the arterial stiffness, which is a strong predictor of major cardiovascular diseases/events (Ben-Shlomo et al., 2014; Vlachopoulos et al., 2010). In addition, experimental studies have showed impairments in post-prandial insulin sensitivity and glucose levels using prolonged/uninterrupted sitting models (Loh et al., 2020). Taken together, our findings suggest that the participants are more vulnerable to a cardiometabolic disturbance cascade during the COVID-19 pandemic, which may potentially increase their risk for cardiovascular and metabolic diseases. Thus, prolonged/uninterrupted SB should be considered as a target for management during the COVID-

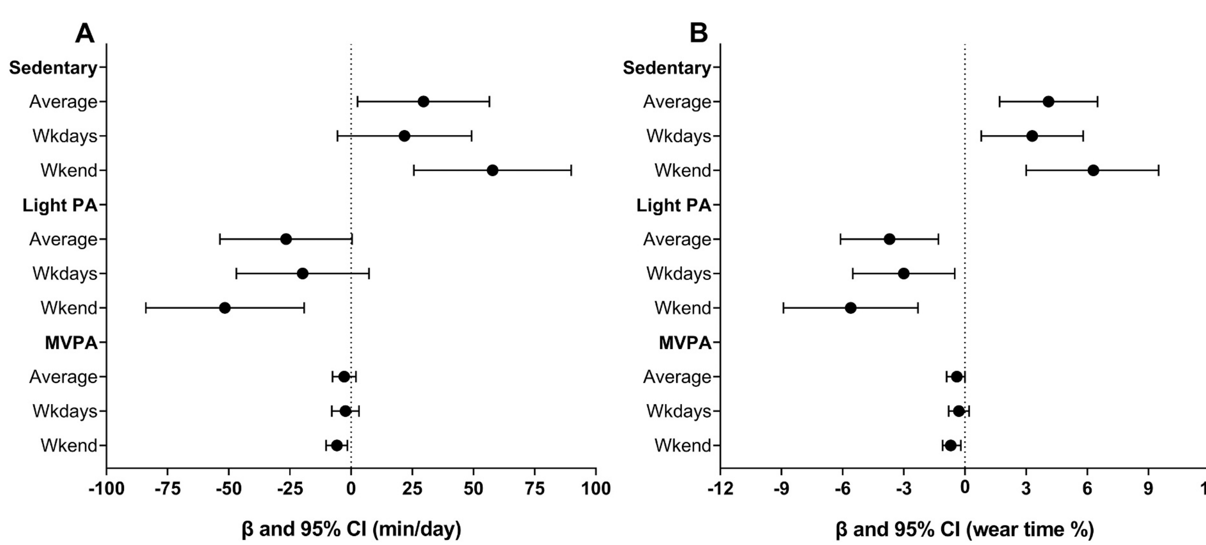

Fig. 1. Change in volume of physical activity and sedentary behavior during the COVID-19 pandemic in hypertensive older adults (n = 35). Panel A: physical activity and sedentary behavior volume in minutes per day. Panel B: physical activity and sedentary behavior volume in accelerometer wear time %. Values are expressed as coefficient estimates (β) and 95% confidence interval (CI). MVPA, moderate to vigorous physical activity; PA, physical activity.

Table 3
Pattern of physical and sedentary behavior before and during the COVID-19 pandemic in hypertensive older adults (n = 35).

	Before	During	β[a]	SE	95% CI	*p*-Value
	EMM (95% CI)	EMM (95% CI)				
Sedentary behavior						
Average						
Sedentary bouts ≥10 min, bouts/day	18.7 (17.6, 19.8)	19.8 (18.7, 20.8)	1.1	0.6	−0.1, 2.3	0.0783
Sedentary bouts ≥30 min, bouts/day	3.7 (3.2, 4.3)	4.4 (3.9, 4.9)	0.7	0.3	0.1, 1.2	**0.0138**
Sedentary time bouts ≥10 min, min/day	410.9 (378.5, 443.3)	452.9 (420.5, 485.3)	42.0	16.8	8.3, 75.8	**0.0158**
Sedentary time bouts ≥30 min, min/day	170.3 (143.2, 197.5)	208.0 (180.8, 235.1)	37.7	12.1	13.2, 62.1	**0.0033**
Length of sedentary bouts, min/day	6.3 (5.8, 6.8)	7.2 (6.7, 7.7)	0.9	0.2	0.4, 1.3	**0.0006**
Breaks ≥1 min, breaks/day	104.3 (99.8, 108.8)	98.3 (93.8, 102.8)	−6.0	2.4	−10.8, −1.2	**0.0157**
Breaks ≥5 min, breaks/day	17.9 (15.8, 19.9)	15.6 (13.5, 17.6)	−2.3	1.0	−4.4, −0.2	**0.0294**
Break rate ≥ 1 min, breaks/h	6.4 (6.2, 6.7)	6.1 (5.8, 6.3)	−0.3	0.1	−0.6, −0.1	**0.0097**
Break rate ≥ 5 min, breaks/h	1.1 (1.0, 1.3)	0.9 (0.8, 1.0)	−0.2	0.1	−0.3, −0.1	**0.0004**
Weekdays						
Sedentary bouts ≥10 min, bouts/day	19.2 (18.1, 20.3)	19.7 (18.6, 20.8)	0.5	0.6	−0.8, 1.8	0.4177
Sedentary bouts ≥30 min, bouts/day	3.8 (3.2, 4.4)	4.4 (3.9, 5.0)	0.6	0.3	0.0, 1.2	**0.0415**
Sedentary time bouts ≥10 min, min/day	421.2 (387.7, 454.7)	451.8 (418.3, 485.3)	30.6	17.4	−4.3, 65.6	0.0846
Sedentary time bouts ≥30 min, min/day	175.2 (147.0, 203.3)	208.6 (180.4, 236.7)	33.4	14.3	4.7, 62.1	**0.0234**
Length of sedentary bouts, min/day	6.4 (5.9, 6.9)	7.1 (6.6, 7.6)	0.7	0.2	0.2, 1.2	**0.0054**
Breaks ≥1 min, breaks/day	105.1 (100.3, 109.8)	100.1 (95.4, 104.8)	−5.0	2.5	−10.1, 0.2	0.0573
Breaks ≥5 min, breaks/day	17.9 (15.8, 19.9)	16.2 (14.1, 18.3)	−1.6	1.1	−3.8, 0.6	0.1416
Break rate ≥ 1 min, breaks/h	6.4 (6.1, 6.7)	6.1 (5.8, 6.4)	−0.3	0.1	−0.6, −0.02	**0.0370**
Break rate ≥ 5 min, breaks/h	1.1 (1.0, 1.3)	0.9 (0.8, 1.1)	−0.2	0.1	−0.3, −0.1	**0.0046**
Weekend						
Sedentary bouts ≥10 min, bouts/day	17.6 (16.2, 18.9)	19.8 (18.5, 21.2)	2.3	0.8	0.6, 3.9	**0.0085**
Sedentary bouts ≥30 min, bouts/day	3.5 (2.8, 4.1)	4.4 (3.8, 5.1)	1.0	0.4	0.2, 1.8	**0.0137**
Sedentary time bouts ≥10 min, min/day	383.4 (346.4, 420.5)	457.3 (420.3, 494.3)	73.9	20.8	31.7, 116.0	**0.0011**
Sedentary time bouts ≥30 min, min/day	155.4 (121.7, 189.1)	209.8 (176.1, 243.5)	54.4	17.9	18.2, 90.7	**0.0044**
Length of sedentary bouts, min/day	6.2 (5.6, 6.8)	7.5 (6.9, 8.1)	1.3	0.4	0.5, 2.0	**0.0018**
Breaks ≥1 min, breaks/day	102.0 (96.8, 107.2)	94.0 (88.8, 99.2)	−8.0	3.5	−15.1, −0.9	**0.0284**
Breaks ≥5 min, breaks/day	18.3 (16.0, 20.7)	13.7 (11.3, 16.1)	−4.6	1.2	−7.0, −2.2	**0.0003**
Break rate ≥ 1 min, breaks/h	6.5 (6.1, 6.8)	6.0 (5.6, 6.3)	−0.5	0.2	−0.9, −0.05	**0.0310**
Break rate ≥ 5 min, breaks/h	1.2 (1.0, 1.3)	0.9 (0.7, 1.0)	−0.3	0.1	−0.4, −0.2	**0.0001**
Physical activity						
Average						
Light PA in bouts ≥10 min, bouts/day	4.0 (3.2, 4.8)	3.8 (3.0, 4.6)	−0.2	0.4	−1.1, 0.7	0.6973
Light PA in bouts ≥10 min, min/day	60.9 (47.6, 74.3)	56.6 (43.3, 70.0)	−4.3	7.5	−19.4, 10.8	–
Sqrt Light PA in bouts ≥10 min, min/day	7.4 (6.5, 8.3)	6.9 (6.1, 7.8)	−0.5	0.5	−1.4, 0.5	0.3164
MVPA in bouts ≥10 min, bouts/day	0.1 (0.0, 0.2)	0.2 (0.1, 0.3)	0.1	0.1	−0.1, 0.2	–
Sqrt MVPA in bouts ≥10 min, bouts/day	0.2 (0.1, 0.3)	0.2 (0.1, 0.4)	0.0	0.1	−0.1, 0.1	0.7545
MVPA in bouts ≥10 min, min/day	2.6 (−0.4, 5.6)	4.6 (1.5, 7.6)	2.0	1.4	−0.9, 4.9	–
Sqrt MVPA in bouts ≥10 min, min/day	0.9 (0.4, 1.5)	1.1 (0.5, 1.6)	0.2	0.3	−0.4, 0.7	0.5916
Weekdays						
Light PA in bouts ≥10 min, bouts/day	3.9 (3.1, 4.7)	3.7 (2.9, 4.5)	−0.2	0.4	−1.1, 0.7	0.6910
Light PA in bouts ≥10 min, min/day	58.0 (45.3, 70.7)	54.4 (41.7, 67.1)	−3.5	7.5	−18.6, 11.5	–
Sqrt Light PA in bouts ≥10 min, min/day	7.2 (6.3, 8.1)	6.8 (5.9, 7.7)	−0.4	0.5	−1.5, 0.6	0.4008
MVPA in bouts ≥10 min, bouts/day	0.2 (0.0, 0.3)	0.2 (0.1, 0.3)	0.1	0.1	−0.1, 0.2	–
			0.0	0.1		0.9831

(continued on next page)

Table 3 (*continued*)

	Before EMM (95% CI)	During EMM (95% CI)	β[a]	SE	95% CI	p-Value
Sqrt MVPA in bouts ≥10 min, bouts/day	0.2 (0.1, 0.4)	0.2 (0.1, 0.4)			−0.1, 0.1	
MVPA in bouts ≥10 min, min/day	3.0 (−0.2, 6.2)	4.7 (1.5, 8.0)	1.8	1.6	−1.5, 5.0	–
Sqrt MVPA in bouts ≥10 min, min/day	1.0 (0.4, 1.6)	1.1 (0.5, 1.6)	0.1	0.3	−0.6, 0.7	0.8635
Weekend						
Light PA in bouts ≥10 min, bouts/day	4.5 (3.4, 5.6)	3.9 (2.8, 5.0)	−0.6	0.6	−1.7, 0.6	–
Sqrt Light PA in bouts ≥10 min, bouts/day	2.0 (1.7, 2.2)	1.7 (1.5, 2.0)	−0.2	0.1	−0.5, 0.1	0.1451
Light PA in bouts ≥10 min, min/day	72.4 (53.0, 91.7)	58.5 (39.2, 77.8)	−13.9	10.5	−35.2, 7.4	–
Sqrt Light PA in bouts ≥10 min, min/day	7.7 (6.6, 8.9)	6.6 (5.4, 7.8)	−1.1	0.6	−2.4, 0.1	0.0807
MVPA in bouts ≥10 min, bouts/day	0.1 (0.0, 0.3)	0.1 (0.0, 0.3)	0.0	0.1	−0.1, 0.1	–
Sqrt MVPA in bouts ≥10 min, bouts/day	0.1 (0.0, 0.3)	0.1 (0.0, 0.2)	−0.0	0.1	−0.1, 0.1	0.8382
MVPA in bouts ≥10 min, min/day	2.6 (−0.3, 5.4)	3.0 (0.2, 5.9)	0.5	1.1	−1.7, 2.6	–
Sqrt MVPA in bouts ≥10 min, min/day	0.6 (0.1, 1.1)	0.6 (0.1, 1.1)	0.0	0.2	−0.5, 0.5	0.9153

Values are expressed as estimated marginal means (EMM), coefficient estimates (β), standard error (SE), and 95% confidence interval (CI).
Bold values indicate significance at $p < 0.05$.
Abbreviations: PA, physical activity; MVPA, moderate to vigorous physical activity; Sqrt, square root.
[a] Model adjusted for accelerometer wear time, except for the variables of length of sedentary bouts and break rate.

19 pandemic in hypertensive older adults.

Additional changes in movement behavior which have occurred in the present study were a reduction in steps per day and time spent in light PA. It seems that the majority of time spent in steps per day and light PA before the COVID-19 pandemic was reallocated for SB, given that the reduction in time spent in moderate-vigorous PA was modest and the individuals already had a very low PA level in this intensity. Evidence has emerged in more recent years showing that in addition to moderate-vigorous PA, the amount of steps per day (Saint-Maurice et al., 2020) and time spent in light PA seem to play a role in reducing mortality risk (Ku et al., 2020), although its protective mechanisms are less known. In a prospective population-based cohort study of older men from the UK, each additional 30 min spent in SB and light PA were associated with a hazard ratio for all-cause mortality of 1.17 (95% CI, 1.10 to 1.25) and 0.83 (95% CI 0.77 to 0.90), respectively (Jefferis et al., 2019). In addition, each additional 1000 steps/day were associated with a hazard ratio for all-cause mortality of 0.84 (95% CI 0.78 to 0.91) (Jefferis et al., 2019). Therefore, in addition to decreasing SB, two additional targets for management during the COVID-19 pandemic are the increase in the amount of steps per day and time spent in light PA, which were dramatically decreased on the weekend (~1700 steps/day and ~51 min/day, respectively).

Moderate-vigorous PA is the core component of PA guidelines given its well-known benefits. Despite this, the majority of older adults do not perform the recommended amount of moderate-vigorous PA (i.e. <150 min/week) (Lee et al., 2012). In our study only 22.9% (n = 8) of the participants performed 150 min/week of moderate-vigorous PA before and during COVID-19 pandemic. A longitudinal analysis of ~150,000 individuals aged 45+ years about the joint and stratified associations of time spent sitting and in moderate-vigorous PA with all-cause and cardiovascular disease mortality recently showed that a high sitting time (≥8 h/day) among inactive individuals (i.e. <150 min/week of moderate-vigorous PA) was associated with the highest all-cause and cardiovascular mortality risk (Stamatakis et al., 2019). Interestingly, such association was attenuated in active (150–299 min/week) individuals, while it was eliminated in more active (300–419 min/week) and highly active (≥420 min/week) individuals (Stamatakis et al., 2019). Similar results were previously found in a harmonized meta-analysis including more than 1 million individuals (Ekelund et al., 2016). Together, these evidences (Ekelund et al., 2016; Stamatakis et al., 2019) suggest that high moderate-vigorous PA levels might have a protective effect against the harmful impact of SB. However, the potential protective effect of PA against SB-induced risk seems to be dependent of a high amount of moderate-vigorous PA (≥60 min/day) (Ekelund et al., 2016; Stamatakis et al., 2019), which is very uncommon in hypertensive older adults. Therefore, it seems unrealistic to propose home-based countermeasures delivered to increase the moderate-vigorous PA levels of these individuals in a great magnitude during the COVID-19 pandemic. Feasible home-based actions focusing on reducing the time spent in prolonged/uninterrupted SB, reallocating time for PA independent of its intensity, seems to be more realistic actions.

Based on our findings, a rule of thumb seems to be “move more, sit less, more often” (Dempsey et al., 2018), particularly at home. Although challenging, some actions might be implemented to elicit healthier movement behavior: i) increase time spent in moderate-vigorous PA by home-based aerobic exercises (e.g. walking in place, walking, dancing), bodyweight exercises (e.g. chair squat, wall push-ups, calf raises), and household chores (e.g. cleaning, dusting or vacuuming), trying to meet 150 min/week (Pescatello et al., 2015); and ii) decrease the time spent in SB (i.e. <8 h/day) (Ekelund et al., 2019; Ku et al., 2019; Patterson et al., 2018) and breaking up prolonged SB with light PA (3–5 min every 20–30 min of SB) (Loh et al., 2020). The accumulation of PA at home elicits a blood pressure-lowering effect in individuals with hypertension, contributing to better BP control (Padilla et al., 2005). Regular breaks in SB every 30 min with 3–5 min of light PA (aerobic or resistance-based activities) are able to attenuate post-prandial glucose, insulin, and triglycerides (Dempsey et al., 2016; Loh et al., 2020). The combination of moderate walking in the morning with regular breaks in SB (3 min of light walking every 30 min) may have an additional blood pressure-lowering effect in comparison to walking without breaks in SB throughout the day (Wheeler et al., 2019). In addition, other home-based countermeasures to attenuate the deleterious effects of prolonged sitting time on vascular health could be implemented by hypertensive older adults such as warm water immersion (ankle level, 42 °C, 30 min), fidgeting/shaking legs (1 min on/4 min off), and adjustments in their seated position (Padilla and Fadel, 2017).

This study has limitations which should be mentioned. First, this study was not a priori designed to investigate the impact of COVID-19 pandemic on movement behavior in hypertensive older adults. It is an exploratory analysis that has included a sample of participants who have been screed for a clinical trial that was interrupted due to the COVID-19 pandemic. Second, this study included medicated hypertensive older adults aged 60–80 years without known cardiovascular diseases (i.e. coronary heart disease, chronic heart failure). Therefore, our results should be interpreted with caution and not generalized for other hypertensive populations. Despite the above-mentioned limitations, our preliminary findings might contribute to better understanding of the unhealthy changes in movement behavior during the COVID-19 pandemic and guide future feasible preventive and therapeutic actions for hypertensive older adults.

5. Conclusion

The COVID-19 pandemic may elicit unhealthy changes in movement behavior in hypertensive older adults, characterized by an increase in time spent in SB and a decrease in time spent in PA, especially on weekend. Further studies involving larger samples are needed to confirm our preliminary results.

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Rodrigo A.V. Browne: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Project administration, Writing – original draft. **Geovani A.D. Macêdo:** Methodology, Formal analysis, Data curation, Writing – original draft. **Ludmila L.P. Cabral:** Methodology, Investigation, Data curation, Writing – review & editing. **Gledson T.A. Oliveira:** Investigation, Data curation, Writing – review & editing. **Andres Vivas:** Investigation, Data curation, Writing – review & editing. **Eduardo B. Fontes:** Conceptualization, Supervision, Resources, Writing – review & editing. **Hassan M. Elsangedy:** Conceptualization, Supervision, Resources, Writing – review & editing. **Eduardo C. Costa:** Conceptualization, Methodology, Supervision, Project administration, Resources, Funding acquisition, Writing – original draft.

Declaration of competing interest

The authors have no conflicts of interest to declare.

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Appendix A. Supplementary data

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