Archives of Gerontology and Geriatrics 94 (2021) 104354

Contents lists available at ScienceDirect

Archives of Gerontology and Geriatrics

journal homepage: www.elsevier.com/locate/archger

Housing type is associated with objectively measured changes in movement behavior during the COVID-19 pandemic in older adults with hypertension: An exploratory study

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ARTICLE INFO

Keywords:
Coronavirus
Social distancing
Aging
Physical activity
Sedentary behavior

ABSTRACT

Purpose: To investigate the association between housing characteristics with objectively measured changes in physical activity (PA) and sedentary behavior (SB) during the COVID-19 pandemic in older adults with hypertension.

Methods: Thirty-five older adults with hypertension were included in this exploratory study. Accelerometer-based PA and SB measures were assessed before and during a period of social distancing policy imposed due to the COVID-19 pandemic. Housing type, housing surface area and household size were tested as predictors of changes in PA and SB. A generalized linear mixed model was used for the analysis.

Results: Housing type was associated with changes in PA and SB. Individuals residing in an apartment showed a greater decrease in light PA on weekdays ($\beta = -65$ min/day, $p=0.035$) and a trend for an increase in SB ($\beta = 55$ min/day, $p=0.056$) compared to those residing in a detached house. Individuals residing in a row house showed a greater decrease in moderate-vigorous PA ($\beta = -10$ min/day, $p=0.037$) and steps/day ($\beta = -2064$, $p=0.010$) compared to those residing in a detached house. Individuals residing in an apartment showed a greater decrease in light PA on the weekends ($\beta = -83$ min/day, $p=0.015$) and an increase in SB ($\beta = 72$ min/day, $p=0.036$) compared to those residing in a detached house. No association was found for housing surface area and household size.

Conclusions: Older adults with hypertension residing in an apartment or row house have greater unhealthy changes in movement behavior during the COVID-19 pandemic. Further studies are needed to confirm our preliminary findings.

1. Introduction

The coronavirus disease 2019 (COVID-19) is an ongoing pandemic that has affected several countries worldwide (World Health Organization, 2020). To date, more than 88 million cases and 1.9 million deaths have been reported across the globe (World Health Organization, 2020). Older adults and those with chronic diseases such as hypertension have an increased risk of infection and severity of COVID-19 (Espinosa et al., 2020; Yang et al., 2020). Social distancing has been one of the most important public health policies to mitigate the COVID-19 pandemic (Aquino et al., 2020). Social distancing policy is characterized by mobility restriction in public areas and 'stay-at-home' recommendation, mainly for the high-risk groups for COVID-19 severity (Aquino et al., 2020). Thus, this scenario may contribute to individuals spending more time inside their homes. Although the benefits of social distancing policy to combat the COVID-19 pandemic is well-recognized, we have reported by accelerometer-based analysis that older adults with hypertension have reduced their time spent in physical activities (PA) and increased sedentary behavior (SB) during the pandemic (Browne et al., 2020). Interestingly, the greater changes have occurred on the weekend

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https://doi.org/10.1016/j.archger.2021.104354

Received 20 October 2020; Received in revised form 19 January 2021; Accepted 21 January 2021

Available online 27 January 2021

(Browne et al., 2020).

Housing characteristics (e.g. housing type, housing surface area and household size) are associated with PA and SB levels (McKee et al., 2015; Pettigrew et al., 2020; Saidj et al., 2015; Svensson et al., 2017). Older adults who reside in detached house have higher PA level than those who reside in apartments, row house and semi-detached house (McKee et al., 2015). Individuals who reside in apartment spend less time in domestic PA and more time in SB than those who reside in house (Saidj et al., 2015; Svensson et al., 2017). Moreover, smaller housing surface area or household size also was associated with more time in SB (Saidj et al., 2015). In a longitudinal study, housing type and housing surface area did not predict changes in SB over 5 years, but the decrease in household size number was associated with an increase in SB (Saidj et al., 2015). Despite the findings of previous studies, it is unclear whether housing characteristics are associated with changes in PA and SB during a period of social distancing policy, which includes a 'stay-at-home' recommendation due to the COVID-19 pandemic. Therefore, this exploratory study investigated the association between housing characteristics with objectively measured changes in PA and SB during a period of social distancing policy imposed due to COVID-19 pandemic in older adults with hypertension.

2. Methods

2.1. Study design

This is an exploratory study, which is a secondary analysis of a previous research designed to investigate the initial impact of social distancing policy imposed due to COVID-19 on objectively measured PA and SB in older adults with hypertension involved in an interrupted clinical trial. Briefly, a sample of Brazilian older adults with hypertension who were screened for the Hypertension EXercise Approaches study (HEXA study; 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 in the city of Natal, Brazil. For more details, see Browne et al. (2020). This observational study was approved by the Research Ethics Board at the Onofre Lopes University Hospital (protocol 4.005.835/2020) and conducted according to the Declaration of Helsinki. The participants were informed about all study procedures and provided written informed consent.

2.2. Participants

The HEXA study was interrupted immediately after the first case of COVID-19 in the city of Natal in March 2020. A total of 41 participants were screened for the HEXA study before the period of social distancing policy (from January to March 2020). Among these participants, only 36 agreed to participate in the present study. The eligibility criteria of the HEXA study are available in the Brazilian Clinical Trials Registry (http://ensaiosclinicos.gov.br/rg/RBR-4ntszb/). The main inclusion criteria were: aged 60–80 years; medical diagnosis of hypertension; not being engaged in a regular PA program in the past three months; being physically inactive (i.e. < 150 min/wk of moderate-vigorous PA). The main exclusion criteria were: previous cardiovascular events or diseases; uncontrolled hypertension (> 160/105 mmHg); contraindications to exercise, as indicated on the cardiopulmonary exercise testing; osteomioarticular injuries that limit the ability to exercise; neurological progressive disorders. Most of these participants met the eligibility criteria of the HEXA study, except 8 participants who were considered physically active by accelerometer-based analysis (i.e. ≥ 150 min/wk of moderate-vigorous PA). However, for the current exploratory study, the 8 physically active participants have been included. Nine of the 36 participants who agreed to participate in the present study were in the familiarization period of the interrupted clinical trial (< 1 month; 3 weekly aerobic exercise sessions of 15–20 minutes) and 27 were screened, but have not begun the familiarization with the exercise intervention.

2.3. Before the period of social distancing policy imposed due to the COVID-19 pandemic

An initial screening was carried out at the Department of Physical Education of the Federal University of Rio Grande do Norte (UFRN) before the period of social distancing policy imposed due to COVID-19 pandemic, including medical history, medication use, sociodemographic (age, sex, education, marital status) and behavioral (smoking status, alcohol use, exercise practice) characteristics, clinical examination, and accelerometer-based PA and SB measures. A clinical examination was performed with anthropometric (weight and height) and resting blood pressure (BP) measurements. Body mass index (BMI) was calculated as weight divided by height squared, and categorized into normal weight (< 27.0 kg/m^2), overweight (27.0–29.9 kg/m^2) and obese (≥ 30.0 kg/m^2). Resting BP was measured in a seated position using an oscillometric device (Omron HEM-780-E, Kyoto, Japan) in triplicate with 2-minute interval between each measure. The average value of the last two measures was considered for analysis (Malachias et al., 2016), and categorized into controlled BP (< 140/90 mmHg) and uncontrolled BP (≥ 140/90 mmHg). The cardiovascular disease (CVD) risk score was categorized into low, moderate and high risk by the Framingham risk score, considering the following criteria: age, sex, smoking, BMI, systolic BP, treatment for hypertension and diabetes (D'Agostino et al., 2008). The total weighted accumulation (weekdays and weekend) of PA measured by accelerometer for 7 days was considered for the classification of PA level. Based on the moderate-vigorous PA, the older adults were classified as: physically active (≥ 150 min/wk of moderate-vigorous PA) or inactive (< 150 min/wk of moderate-vigorous PA) (Chodzko-Zajko et al., 2009).

2.4. During the period of social distancing policy imposed due to the COVID-19 pandemic

Since the interruption of the HEXA study on March 2020, all participants have been receiving weekly phone calls from the research staff to be monitored regarding COVID-19 symptoms. The participants were invited by phone calls to participate in the present study after a 11-week period from the beginning of social distancing policy in the city of Natal, Brazil. Accordingly to the information reported by the participants by weekly phone calls, none of them were involved in an exercise training program following the interruption of the HEXA study. Given that there is no evidence that exercise interventions modify the non-exercise PA level (Fedewa et al., 2017) and that all participants were assessed 11 weeks after the interruption of HEXA study, we have included the 9 participants who were in the familiarization period and the 27 participants who were only screened, but have not begun the familiarization with the exercise intervention in the interrupted clinical trial. 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 7 consecutive days. The accelerometer-based PA and SB measures during the period of social distancing policy occurred during a period of high mobility restriction in the public areas within the city of Natal, which included 'stay-at-home' recommendation, especially for older adults and high-risk individuals – those with non-communicable chronic diseases. In addition to the accelerometer-based PA and SB measures, information about housing characteristics that the participants were residing in during the social distancing period, including housing type, housing surface area (m^2) and household size (i.e. number of persons residing in the home) were collected by phone calls. Housing type was categorized into apartment, row house and detached house. Housing surface area was categorized by the tertiles: ≤ 105 m^2, 106–249 m^2, and ≥ 250 m^2. Household size was categorized into 1–2 persons and 3+ persons.

2.5. Objectively measured physical activity and sedentary behavior

PA and SB were objectively measured by accelerometry (GT3X, Actigraph LLC, Pensacola, USA). All participants were instructed to wear the accelerometer on their right hip during 7 consecutive days, including awake and asleep periods, and to remove it during bathing. They also filled out a diary describing the time they took off the accelerometer during the awake period, went to bed and waking up. A sampling rate of 60 Hz with a period of 60 seconds was used with the normal filter enabled. Non-wearing time was defined as ≥ 90 consecutive minutes of zero counts with a tolerance of up to 2 minutes of ≥ 100 counts/min (Choi et al., 2011). Participants with at least three valid weekdays of accelerometer wearing time (≥ 600 min/day) with at least one weekend day, totaling at least four valid days, were included in the data analysis (Trost et al., 2005). Although there is no consensus on the cut-off points for older adults, we used those which are most commonly reported in this population (Migueles et al., 2017). The cut-offs in counts per minutes to define SB, light PA, and moderate-vigorous PA were: 0–99, 100–1951, and ≥ 1952, respectively (Freedson et al., 1998; Matthews et al., 2008). PA and SB measures were analyzed as weekdays and weekend using the ActiLife version 6.13.3.2 software program. The variables considered for analysis were: steps/day; time spent in SB, light PA, and moderate-vigorous PA (in minutes per day).

2.6. Statistical analysis

Descriptive data are presented as mean ± standard deviation (SD), absolute and relative (%) frequencies. A generalized linear mixed model with subject as a random effect and time period (after vs. before the 'stay-at-home' recommendation; i.e. binary variable) and predictors as fixed effects was used to assess the housing characteristics associated to objectively measured changes in PA and SB, controlling for: a) accelerometer wear time; b) age, sex, education and accelerometer wear time. For all analyses, the baseline assessment of the participants for the original HEXA study, which have occurred between January to March 2020, was considered as 'before' the pandemic. All assessments 'during' the pandemic have occurred in the same week of June 2020. A robust estimation was used for the fixed effects model. The generalized linear model was used to compare the housing surface area between housing types. The model results were expressed as coefficient estimates (β) and its 95% Wald confidence intervals (CI), estimated marginal means (EMM) ± standard error (SE), pairwise contrasts and its 95% Wald CI. Residuals distribution was verified using the normal Q-Q plot. A two-tailed $p < 0.05$ was considered statistically significant for all analyses. Statistical analyses were performed using IBM SPSS Statistics for Win/v.26.0 (IBM Corp., Armonk, NY).

3. Results

3.1. Sample characteristics

Among the 41 participants invited to participate in the study, five participants declined to participate (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 data. Thus, a total of 35 older adults with hypertension were included in the final analysis. Table 1 shows the characteristics of the included participants. Most participants were women (65.7%), physically inactive (77.1%), residing in a detached house (57.1%), and with three or more relatives (51.4%). Only 14.3% (n = 5) of participants were residing in an apartment. All apartments were located in condominium buildings, which contain concierge, security service, private garage and leisure area. The use of condominiums' leisure area was restricted during the period of data collection. All participants were taking anti-hypertensive medication(s). In addition, the participants had a moderate CVD risk (42.9%) or high CVD risk (57.1%). Approximately one-third of participants had uncontrolled BP (37.1%) and one-fourth were ex-smokers (22.9%).

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

	Mean ± SD or n (%)
Age, yrs	65.6 ± 3.8
Females	23 (65.7%)
Partner	17 (48.6%)
Post-secondary education	10 (28.6%)
BMI, kg/m^2	27.4 ± 3.5
Resting SBP, mmHg	134.3 ± 18.3
Resting DBP, mmHg	74.1 ± 9.4
Uncontrolled BP	13 (37.1%)
Hypertension diagnosis, yrs	12.1 ± 9.1
Risk factors	
Diabetes	12 (34.3%)
Dyslipidemia	18 (51.4%)
Overweight	12 (34.3%)
Obesity	5 (14.3%)
Ex-smoker	8 (22.9%)
Physically inactive	27 (77.1%)
CVD risk, %	27.5 ± 14.8
Moderate CVD risk	15 (42.9%)
High CVD risk	20 (57.1%)
Housing type	
Apartment	5 (14.3%)
Row house	10 (28.6%)
Detached house	20 (57.1%)
Housing surface area	
≤ 105 m^2	11 (31.4%)
106–249 m^2	12 (34.3%)
≥ 250 m^2	12 (34.3%)
Household size	
1–2 persons	17 (48.6%)
3+ persons	18 (51.4%)

Values expressed as mean ± SD and absolute (n) and relative frequencies (%).
Abbreviations: BMI, body mass index; CVD, cardiovascular disease; BP, blood pressure; DBP, diastolic blood pressure; SBP, systolic blood pressure.

3.2. Association between housing characteristics and changes in physical activity and sedentary behavior

Table 2 and Figure 1 show the results of housing type, housing surface area and household size as predictors of objectively measured changes in PA and SB during the COVID-19 pandemic, controlling for the accelerometer wearing time. Housing type was a significant predictor of objectively measured changes in PA and SB ($p < 0.05$), but housing surface area and household size were not significant predictors ($p > 0.05$). Age, sex, education, BMI and CVD risk were not associated with objectively measured changes in PA and SB ($p > 0.05$; data not shown). Despite this, we examined the models of housing type, housing surface area and household size as predictors of objectively measured changes in PA and SB during the COVID-19 pandemic controlling for the age, sex, education and accelerometer wearing time (Supplementary Table 1). The results of all models remained unchanged.

Regarding the weekdays, residing in an apartment showed a greater decrease in light PA (β = –65 min/day, p = 0.035) and a trend toward significance for an increase in SB (β = 55 min/day, p = 0.056) compared to those residing in a detached house. Participants residing in a row house showed a greater decrease in moderate-vigorous PA (β = –10 min/day, p = 0.037) and steps/day (β = –2,064, p = 0.010) compared to those residing in a detached house. Residing in an apartment showed a greater decrease in light PA on the weekend (β = –83 min/day, p = 0.015) and a greater increase in SB (β = 72 min/day, p = 0.036) than residing in a detached house. Despite this, participants residing in a detached house showed a decrease in moderate-vigorous PA compared to those residing in an apartment (β = –11 min/day, p = 0.016).

Additional analyzes were performed to check whether the housing

Table 2
Generalized linear mixed models of housing type, housing surface area and household size as predictors of objectively measured changes in physical activity and sedentary behavior during the period of social distancing policy due to COVID-19 pandemic in older adults with hypertension (n = 35).

	N	Δ Sedentary, min/day β (95% CI)	P	Δ Light PA, min/day β (95% CI)	P	Δ MVPA, min/day β (95% CI)	P	Δ Steps/day β (95% CI)	P
Weekdays									
Housing type									
Apartment	5	55.1 (–1.4, 111.7)	0.056	–65.0 (–125.2, –4.9)	**0.035**	9.8 (–5.4, 24.9)	0.201	–79 (–1763, 1604)	0.925
Row house	10	15.8 (–31.3, 62.9)	0.506	–6.1 (–51.5, 39.4)	0.791	–9.7 (–18.7, –0.6)	**0.037**	–2064 (–3624, –503)	**0.010**
Detached house	20	Ref.		Ref.		Ref.		Ref.	
Housing surface area									
≤ 105 m^2	11	–0.7 (–62.9, 61.4)	0.981	1.5 (–60.3, 63.3)	0.962	–1.0 (–10.4, 8.4)	0.840	–427 (–1820, 966)	0.543
106–249 m^2	12	24.8 (–36.8, 86.5)	0.424	–25.3 (–87.4, 36.7)	0.417	0.5 (–11.9, 13.0)	0.932	–432 (–2234, 1370)	0.633
≥ 250 m^2	12	Ref.		Ref.		Ref.		Ref.	
Household size									
1–2 persons	17	9.4 (–37.9, 56.7)	0.693	–16.2 (–63.7, 31.2)	0.497	6.9 (–2.2, 16.0)	0.133	691 (–665, 2048)	0.312
≥ 3 persons	18	Ref.		Ref.		Ref.		Ref.	
Weekend									
Housing type									
Apartment	5	72.0 (4.9, 139.0)	**0.036**	–83.1 (–149.8, –16.5)	**0.015**	10.9 (2.1, 19.6)	**0.016**	–150 (–2281, 1980)	0.888
Row house	10	17.9 (–48.3, 84.0)	0.591	–13.3 (–79.7, 53.2)	0.691	–4.6 (–14.0, 4.7)	0.326	–1738 (–3702, 227)	0.082
Detached house	20	Ref.		Ref.		Ref.		Ref.	
Housing surface area									
≤ 105 m^2	11	1.0 (–82.7, 84.8)	0.980	–5.1 (–87.1, 76.9)	0.902	4.3 (–3.5, 12.1)	0.277	–222 (–2168, 1723)	0.820
106–249 m^2	12	6.7 (–66.6, 80.1)	0.855	–2.5 (–77.3, 72.3)	0.947	–4.7 (–15.4, 5.9)	0.376	–1219 (–3000, 563)	0.176
≥ 250 m^2	12	Ref.		Ref.		Ref.		Ref.	
Household size									
1–2 persons	17	50.1 (–6.9, 107.2)	0.084	–51.8 (–109.2, 5.7)	0.077	2.0 (–6.1, 10.2)	0.619	–406 (–2000, 1188)	0.613
≥ 3 persons	18	Ref.		Ref.		Ref.		Ref.	

Values are expressed as coefficient estimates (β) and 95% confidence intervals (CI).
The models were analyzed using a generalized linear mixed model controlling for the accelerometer wearing time.
Bold values indicate significance at $p < 0.05$.
Abbreviations: MVPA, moderate-vigorous physical activity; PA, physical activity.

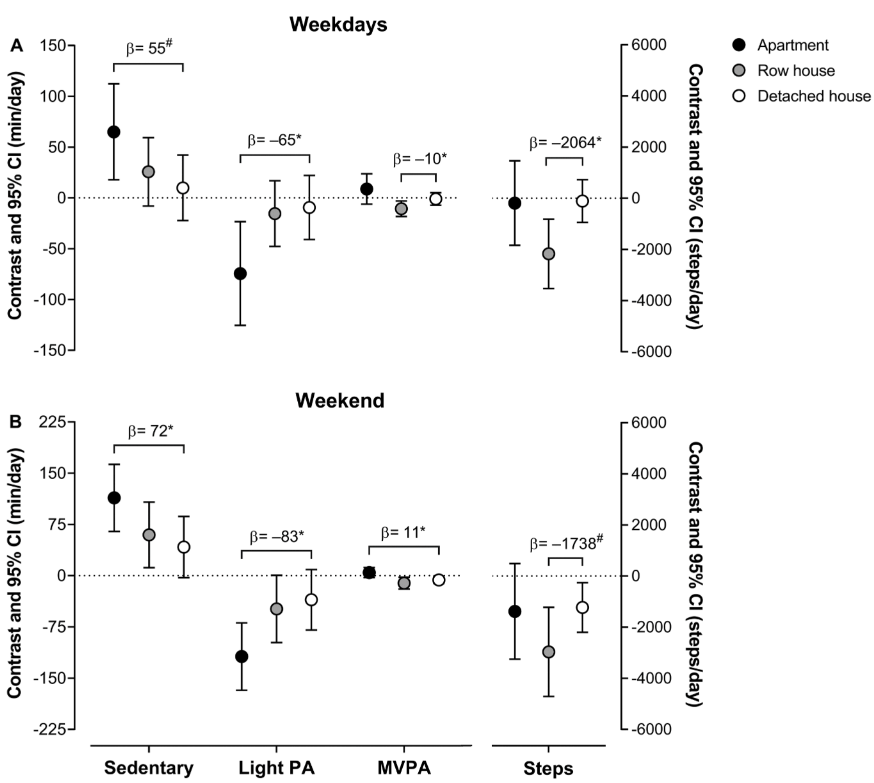

Figure 1. Objectively measured changes in physical and sedentary behavior on weekdays (panel A) and on the weekend (panel B) during the period of social distancing policy due to the COVID-19 pandemic among 35 older adults with hypertension residing in an apartment (n = 5), row house (n = 10) or detached house (n = 20). Values are expressed as contrast estimates and its 95% confidence interval (CI) of the estimated marginal means (EMM) (contrast = EMM of 'during' – EMM of 'before' the COVID-19 pandemic), controlling for the accelerometer wearing time. *P < 0.05; #P < 0.10. Abbreviations: MVPA, moderate-vigorous physical activity; PA, physical activity; β, coefficient estimates (reference group is detached house).

type was associated with objectively measured changes in PA and SB independently of housing surface area and household size. The results remained unchanged after including housing surface area or household size in the models (data not shown). Moreover, housing surface area was compared between the housing types. The detached house (322 m^2, 95% CI 263, 394) had a larger housing surface area ($p < 0.001$) than the row house (127 m^2, 95% CI 92, 175) and apartment (92 m^2, 95% CI 50, 169). There was no significant difference between apartment and row house ($p > 0.05$).

Table 3
Estimated marginal means and pairwise contrasts of objectively measured physical activity and sedentary behavior during the period of social distancing policy due to the COVID-19 pandemic in older adults with hypertension according to housing type (n = 35).

		Sedentary, min/day	Light PA, min/day	MVPA, min/day	Steps/day
Weekdays					
Apartment (n = 5)					
Before	EMM ± SE	695.0 ± 22.2	275.0 ± 24.2	12.8 ± 5.5	4954 ± 472
During	EMM ± SE	760.0 ± 7.4	200.6 ± 6.2	21.6 ± 11.4	4766 ± 1182
During–Before	Contrast (95% CI)	65.0 (17.8, 112.3)	–74.4 (–125.4, –23.4)	8.8 (–6.1, 23.7)	–188 (–1841, 1465)
	P	**0.008**	**0.005**	0.243	0.821
Row house (n = 10)					
Before	EMM ± SE	670.5 ± 15.5	296.0 ± 13.2	16.0 ± 3.6	6362 ± 773
During	EMM ± SE	696.2 ± 23.1	280.6 ± 22.8	5.4 ± 1.5	4190 ± 441
During–Before	Contrast (95% CI)	25.7 (–8.0, 59.3)	–15.4 (–47.7, 16.9)	–10.6 (–18.2, –3.0)	–2173 (–3529, –816)
	P	0.132	0.343	**0.007**	**0.002**
Detached house (n = 20)					
Before	EMM ± SE	655.6 ± 16.3	309.8 ± 15.9	17.2 ± 2.6	5872 ± 405
During	EMM ± SE	665.5 ± 17.1	300.4 ± 14.7	16.3 ± 4.1	5763 ± 578
During–Before	Contrast (95% CI)	9.9 (–22.3, 42.2)	–9.4 (–40.9, 22.2)	–1.0 (–7.1, 5.2)	–109 (–944, 727)
	P	0.541	0.555	0.752	0.795
Weekend					
Apartment (n = 5)					
Before	EMM ± SE	649.8 ± 32.1	283.9 ± 26.3	11.4 ± 7.7	5040 ± 1501
During	EMM ± SE	763.7 ± 17.7	165.5 ± 11.5	16.0 ± 8.4	3659 ± 984
During–Before	Contrast (95% CI)	113.9 (64.8, 162.9)	–118.4 (–167.7, –69.2)	4.6 (–2.7, 11.9)	–1381 (–3252, 490)
	P	**<0.001**	**<0.001**	0.213	0.145
Row house (n = 10)					
Before	EMM ± SE	615.9 ± 18.4	316.5 ± 18.8	12.7 ± 3.7	6372 ± 684
During	EMM ± SE	675.7 ± 31.9	268.0 ± 31.8	1.8 ± 0.8	3404 ± 597
During–Before	Contrast (95% CI)	59.8 (11.8, 107.7)	–48.6 (–97.8, 0.6)	–10.9 (–19.5, –2.4)	–2968 (–4714, –1222)
	P	**0.015**	0.053	**0.013**	**0.001**
Detached house (n = 20)					
Before	EMM ± SE	609.4 ± 21.2	319.2 ± 20.2	16.3 ± 3.8	5781 ± 592
During	EMM ± SE	651.3 ± 19.5	283.9 ± 17.5	10.1 ± 2.7	4550 ± 398
During–Before	Contrast (95% CI)	41.9 (–3.0, 86.7)	–35.3 (–79.5, 8.9)	–6.3 (–11.4, –1.1)	–1230 (–2201, –260)
	P	0.067	0.116	**0.018**	**0.014**

Values are expressed as estimated marginal means (EMM) ± standard error (SE), and pairwise contrasts and its 95% confidence intervals (CI).
The models were analyzed using a generalized linear mixed model controlling for the accelerometer wearing time.
Bold values indicate significance at $p < 0.05$.
Abbreviations: MVPA, moderate-vigorous physical activity; PA, physical activity.

3.3. Within-group changes in physical activity and sedentary behavior according to the housing type

Table 3 shows the within-group changes in PA and SB of participants residing in an apartment, row house and detached house. Before the COVID-19 pandemic, the participants already had low PA (e.g. < 6,500 steps/day; ~15 min/day moderate-vigorous PA) and high SB levels (> 10 h/day) on weekdays and weekend. Regarding the within-group changes on the weekdays, residing in an apartment showed an increase in SB (65 min/day, $p = 0.008$) and a decrease in light PA (–74 min/day, $p = 0.005$). Participants residing in a row house showed a decrease in moderate-vigorous PA (–11 min/day, $p = 0.007$) and steps/day (–2,173, $p = 0.002$). No changes were found for detached house ($p > 0.05$). On weekend, there was an increase in SB among participants residing in an apartment (114 min/day, $p < 0.001$) and row house (60 min/day, $p = 0.015$). There was a decrease in light PA among participants residing in an apartment (–118 min/day, $p < 0.001$) and a trend toward significance for those residing in a row house (–49 min/day, $p = 0.053$). In addition, residing in a row house showed a decrease in moderate-vigorous PA (–11 min/day, $p = 0.013$) and steps/day (–2,968, $p = 0.001$). Participants residing in a detached house showed a decrease in moderate-vigorous PA (–6 min/day, $p = 0.018$) and steps/day (–1,230, $p = 0.014$) on weekend.

4. Discussion

This exploratory study investigated the housing characteristics associated with objectively measured changes in PA and SB during a period of social distancing policy imposed due to the COVID-19 pandemic in older adults with hypertension. The main findings indicate that housing type was associated with changes in PA and SB: i) participants who resided in an apartment showed a greater reduction in the light PA and increase in the SB compared to those who resided in a detached house on weekdays and on weekend; ii) participants who resided in a row house showed a greater reduction in the moderate-vigorous PA and steps/day compared to those who resided in a detached house on weekdays.

Older adults with hypertension are a high-risk group for severity of COVID-19 (Espinosa et al., 2020; Yang et al., 2020), which requires more rigid social distancing policy. The data collection in this study occurred during a period of high mobility restriction in the public areas with a 'stay-at-home' recommendation implemented by the governor of the state of Rio Grande do Norte, Brazil, of which Natal is the capital city. This scenario probably contributed to the participants spending more time inside their homes. Previous studies have shown that housing characteristics (e.g. housing type, housing surface area and household size) are associated with PA and SB levels (McKee et al., 2015; Pettigrew et al., 2020; Saidj et al., 2015; Svensson et al., 2017). However, as observed in Figure 1 and Table 2, our data support the idea that only housing type is associated with changes in PA and SB levels which occurred during the period of social distancing policy imposed due to the COVID-19 pandemic. The participants who resided in an apartment or a row house showed greater unhealthy changes in movement behavior (less PA, more SB). It should be noted that before the period of social distancing the participants who resided in an apartment or a row house already had low PA and high SB levels. However, they showed a greater decrease in the PA and increase in SB levels compared to their peers who resided in a detached house. Therefore, it seems that housing type may contribute to individuals change more or less their movement behavior during the COVID-19 pandemic, particularly during a more rigid period of social distancing policy.

The housing surface area of the apartments and row houses of the participants who resided in these housing types is equivalent to ~29% and ~39%, respectively, of the housing surface area of the detached houses. A larger housing surface area combined with other architecture features such as the presence of backyard and garden might have contributed to participants who resided in detached houses mitigating the unhealthy changes in PA and SB during the period of social distancing period policy, which did not occur with those who resided in apartments or row houses. It is reasonable to think that under a more rigid social distancing period policy, the participants who resided in detached houses had more possibilities to be involved in PA inside their homes, particularly within the domestic and leisure domains. In addition, we believe that as social distancing imposes mobility restriction in the public areas, the participants who resided in apartments and row houses might have reduced their PA levels mainly in the transportation and leisure domains. However, different from those who resided in detached houses, it seems that they were not able to replace the PA performed in the transportation and leisure domains outside for PA inside their homes, potentially due to the limited area and unfavorable architecture features. As a consequence, they might have increased their time in SB such as watching TV. Taken together, this above-mentioned perspective could partially explain the greater reduction in the steps/day, light and moderate-vigorous PA and the increase in the SB observed in the participants who resided in apartments and row houses.

Although not objectively assessed in the present study, it is reasonable to think that the life-space mobility (LSM) of the participants was restricted during the period of social distancing policy. Briefly, LSM refers to the physical and social environment an individual inhabits on a day-to-day basis considering the frequency and independence. LSM is commonly structured into 'life zones', ranging from a restricted and dependent mobility (life-space 0, bedroom) to an unrestricted and independent mobility to travel out of town (life-space 5; unlimited) (Taylor et al., 2019). It should be noted that LSM focuses on the performed actions rather than abilities of an individual, providing a picture of what he/she 'does do' rather than what he/she physically 'can do' (Taylor et al., 2019). All participants from the present study were physically independent. For example, all of them performed a maximal cardiopulmonary exercise test on a treadmill as a part of the HEXA study screening procedures (data not shown). However, due to the COVID-19 pandemic context, it is probable that the LSM of the participants declined and became more concentrated in more restricted 'life zones' (life-space 0; bedroom; life-space 1, home; life-space 2, outside house), independent of their housing types. Studies designed to assess the impact of the COVID-19 pandemic on LSM in older adults are needed to confirm (or not) our assumption.

The unhealthy changes in movement behavior observed during the COVID-19 pandemic in the participants might have health-related consequences involving both physical and mental aspects (Browne et al., 2020; Creese et al., 2020; Werneck et al., 2020; Yamada et al., 2020). As previously suggested (Browne et al., 2020), home-based actions focusing on reducing the time spent in prolonged SB and reallocating time for PA independent of its intensity seems to be more realistic as a first-level approach; i.e. breaking up prolonged leisure-time SB with light PA and doing household chores more frequently. Although more challenging, particularly for individuals who reside in apartments and row houses, a second-level approach could be to include specific exercises focusing on maintaining health-related fitness; i.e. for cardiorespiratory exercises: marching in place, stair climbing, dancing; for muscular strength: bodyweight exercises, such as chair squats, wall push-ups, and calf raises. Workout videos from well-recognized institutions, including simple, low-cost, and safe exercises would be an option: i.e. an online workout video from the National Center on Health, Physical Activity and Disability (https://youtu.be/eLClKvN9Qag). Also, wearable fitness technologies can be useful to help older adults to meet the recommended PA levels. As a public health initiative, governments should consider delivering clear and practical information to older adults on *how* and *why* increasing PA and decreasing SB is important during these challenging times of COVID-19 pandemic. It seems pivotal the inclusion of feasible actions to overcome the new barriers to be physically active imposed by the pandemic in this population. Despite the above-mentioned possibilities, it must be clear that there is no 'one size fits all' solution to reach healthier movement behavior during the COVID-19 pandemic. Our data suggest a need for specific PA interventions delivered to older adults who reside in apartments and row houses, who are more vulnerable to unhealthy changes in movement behavior during the pandemic.

This exploratory study has limitations that should be mentioned. The HEXA study was not originally designed to investigate the changes incurred and housing characteristics associated to PA and SB during the period of social distancing policy imposed due to the COVID-19 pandemic. Environmental hazards in the homes were not considered (e.g. slippery surfaces, no handrail, low lighting and loose rugs). These factors are associated with an increase in the perception of the risk of falls and, therefore, could modify the interaction between movement behavior and housing type in older adults (Valipoor et al., 2020). Although the housing types included in this study were similar to those used in other countries, such as Denmark (Saidj et al., 2015), Australia (Pettigrew et al., 2020), Sweden (Svensson et al., 2017), and Ireland (McKee et al., 2015), we recognize that urban and sociocultural characteristics can make housing types incomparable among countries. This is an exploratory study that included participants who were originally screened for a clinical trial that was interrupted due to the COVID-19 pandemic. The small subgroup of participants residing in an apartment may have underestimated the power of the results; however, it should be noted that there were no cases of outliers in this subgroup. Taken together, our preliminary results should be interpreted with caution and not generalized to all older adults and countries.

5. Conclusion

Older adults with hypertension residing in an apartment or row house have greater unhealthy changes in movement behavior during the COVID-19 pandemic. Further studies are needed to confirm our preliminary findings. It seems important consider specific home-based countermeasures for those who reside in housing types with limited area to move around in order to mitigate the unhealthy changes in movement behavior and its potential health-related consequences.

Funding

This study was supported by the Brazilian Council for Scientific and Technological Development (CNPq; 427729/2018-1). The first author is supported by a PhD scholarship from the Brazilian Coordination of Improvement of Higher Education Personnel (CAPES; 88882.375386/2019-01). The last author is supported by a research productivity grant from CNPq (306744/2019–8).

Declaration of Competing Interest

The authors declare no conflict of interest.

Acknowledgments

The authors would like to thank the participants who volunteered for this study. We also thank Maria Beatriz F. Araújo and Júlio Sócrates for their support in the data collection.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.archger.2021.104354.

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