AUTHOR(S): REID, N., KEOGH, J.W., SWINTON, P., GARDINER, P.A. and HENWOOD, T.R.

TITLE: The association of sitting time with sarcopenia status and physical performance at baseline and 18-month follow up in the residential aged care setting.

YEAR: 2018

Publisher citation: REID, N., KEOGH, J.W., SWINTON, P., GARDINER, P.A. and HENWOOD, T.R. 2018. The association of sitting time with sarcopenia status and physical performance at baseline and 18-month follow up in the residential aged care setting. Journal of aging and physical activity [online], 26(3), pages 445-450. Available from: https://doi.org/10.1123/japa.2017-0204

OpenAIR citation: REID, N., KEOGH, J.W., SWINTON, P., GARDINER, P.A. and HENWOOD, T.R. 2018. The association of sitting time with sarcopenia status and physical performance at baseline and 18-month follow up in the residential aged care setting. Journal of aging and physical activity, 26(3), pages 445-450. Held on OpenAIR [online]. Available from: https://openair.rgu.ac.uk/

Note: This article will be published in a forthcoming issue of the *Journal of Aging and Physical Activity*. This article appears here in its accepted, peer-reviewed form; it has not been copy edited, proofed, or formatted by the publisher.

Section: Original Research

Article Title: The Association of Sitting Time With Sarcopenia Status and Physical Performance at Baseline and 18-Month Follow Up in the Residential Aged Care Setting

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Running Head: Sitting time, sarcopenia and performance over 18 months

Journal: *Journal of Aging and Physical Activity*

Acceptance Date: September 24, 2017

DOI: https://doi.org/10.1123/japa.2017-0204

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The association of sitting time with sarcopenia status and physical performance at baseline and 18-month follow up in the residential aged care setting.

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Abstract

This study investigated the association of sitting time with sarcopenia and physical performance in Residential Aged Care (RAC) residents at baseline and 18-month follow-up. Measures included the International Physical Activity Questionnaire (sitting time), European Working Group definition of sarcopenia, and the Short Physical Performance Battery (physical performance). Logistic regression and linear regression analyses were used to investigate associations. For each hour of sitting the unadjusted odds ratio of sarcopenia was 1.16 (0.98 - 1.37). Linear regression showed that each hour of sitting was significantly associated with a 0.2-unit lower score for performance. Associations of baseline sitting and follow-up sarcopenia status and performance were non-significant. Cross-sectionally, increased sitting time in RAC may be detrimentally associated with sarcopenia and physical performance. Based on current reablement models of care, future studies should investigate if reducing sedentary time improves performance among adults in end of life care.

Key words: Longitudinal; older adults; nursing homes; sedentary time; sedentary behaviour

Older adults living in residential aged care (RAC; also referred to as nursing homes) are a growing segment of the population (de Souto Barreto, 2015). A key challenge in the RAC setting is the prevalence of sarcopenia (Landi et al., 2013; Senior, Henwood , Beller, Mitchell, & Keogh, 2015) and the poor physical function of residents (de Souto Barreto, 2015; Slaughter et al., 2015). The European Working Group on Sarcopenia in Older People (EWGSOP) defines sarcopenia as the presence of low muscle mass as well as poor muscle strength and/or physical performance (Cruz-Jentoft et al., 2010). Sarcopenia is associated with a range of adverse health outcomes, including disability and death (Cruz-Jentoft et al., 2010). Poor physical function, which is a component of sarcopenia and incorporates both muscle mass and physical performance, is associated with an inability to perform daily tasks (e.g., toileting, walking, socialising), increased risk of falls and resultant fractures, increased mortality and reduced quality of life (Bradley, 2013; Wolinsky et al., 2007).

Physical activity guidelines recommend 150 minutes of moderate activity per week to maintain or improve function in healthy community-dwelling older adults. However, this amount of high intensity activity may not be feasible and acceptable to older adults in RAC, who are often admitted because they cannot care for themselves and are often rated as needing a high level of care in activities of daily living, behaviour and complex health care (Australian Institute of Health and Welfare., 2012). Indeed, the majority of older adults in aged care are highly sedentary, with over twelve of their waking hours spent sitting or lying each day (85% of waking hours) (Reid et al., 2013), in contrast to nine hours in community-dwelling older adults (Harvey, Chastin, & Skelton, 2014; Wullems, Verschueren, Degens, Morse, & Onambele, 2016). Rather than introducing structured exercise among a population with a high falls risk, which is three times higher than for people of the same age living in their own home (Hewitt, Refshauge, Goodall, Henwood, & Clemson, 2014), an emphasis on reducing sitting

time may be a more acceptable modality of intervention (Sparling, Howard, Dunstan, & Owen, 2015), that could eventually lead to participation in structured exercise programs.

Few studies have examined the health impacts of high levels of sitting time among RAC residents. Studies from the general population of older adults indicate that sitting time is associated with being overweight or obese, having poor cardiovascular health and physical function, metabolic syndrome, sarcopenia, and increased risk of mortality (Chastin et al., 2015; de Rezende, Rey-Lopez, Matsudo, & Luiz, 2014). Furthermore, previous studies have indicated that there is a link between sedentary time and all-cause mortality (Biddle et al., 2016) with the risk increased by 34% among those who sit for 10 hours or more per day (Chau et al., 2013). However, the majority of studies examining the association of sitting time with sarcopenia and function in older adults have been conducted outside of the RAC population where sitting time is high (Reid et al., 2013). Findings from a small number of emerging studies in the RAC setting suggest an association of extended sitting time with slower gait speed (Ikezoe, Asakawa, Shima, Kishibuchi, & Ichihashi, 2013; Keogh, Senior, Beller, & Henwood, 2015; Rosenberg et al., 2016), poorer balance, lower muscle strength (Ikezoe et al., 2013; Rosenberg et al., 2016), and higher risk of sarcopenia (Senior et al., 2015). However, no studies to date have examined the impact of sitting time on sarcopenia status or function after a follow-up period. To address this short-coming, this study examined the association of sitting time with sarcopenia status and physical performance at baseline, as well as change in sarcopenia status and physical performance after 18 months among RAC residents.

Methods

Study design

An initial cross-sectional study with 18-month follow-up was conducted to assess sarcopenia prevalence and its risk factors. Detailed methods have been published previously

(Henwood, Hassan, Swinton, Senior, & Keogh, 2017; Henwood, Keogh, Reid, Jordan, & Senior, 2014). Briefly, 11 residential aged care facilities agreed to participate, with 273 low, high and dementia care individuals randomly selected from 381 residents eligible for this study. Residents were eligible if they were (i) ≥60 years, (ii) residing in a nursing home and (ii) could provide consent, self or by proxy given directly by the participants' substitute decision maker or verbally to the facility Service Manager. Residents were excluded if they; (i) had a pacemaker; (ii) were end-stage palliative or terminal (iii) had difficult behaviours that would limit data collection; or (iv) had a medical condition or other issue that would limit data collection (e.g., total uncommunicable deafness). One hundred and two residents consented to participate (91 self-consented, 11 consented via proxy).

Consent to the baseline study included agreement to be approached regarding the follow-up assessment. At 18 months' post-baseline assessment, facilities were re-contacted and the follow-up study explained to the Service Manager. Each manager was given a list of participants, with a request to seek consent. Approval for the study was provided by the Human Ethics Committee of the XXX, XXX, and the RAC provider's internal ethics committee. Figure 1 details a recruitment flowchart at baseline and follow-up.

Data Collection

Individual assessments of all participants residing in one nursing home facility were completed before moving to the next nursing home. The research assistant was solely responsible for conducting the assessments with low care participants, while a nursing home staff member was present for assessments involving high care participants.

Measures

All measures used in this study have been validated for use among old and very old adults and have been described in previous publications (Henwood et al., 2014). If a participant

was unable to complete a measure due to health or disability issues the measure was typically excluded. The only exception to this rule was the 2.4-meter walk (which was scored at 0 if unable to complete) so to ensure a measure of physical function was achieved. For individuals who were unable to or did not consent to the bioelectrical impedance analysis (BIA) at follow-up, baseline data were carried forward.

Demographics and health status. Demographic and health data were collected at both baseline and follow-up. From the organizational database, information on date of birth (used to calculate age), gender, and falls history were obtained. Body mass index (BMI) was calculated from height (cm) and weight (kg) using standardized methodologies. Participants were also asked their smoking status (current, past, or never) and if they were physically active now (yes/no). Cognitive impairment and depression were assessed by the Mini-Mental State Examination questionnaire (MMSE) (Folstein, Folstein, & McHugh, 1975) and the Geriatric Depression Scale (GDS-15) (Woodford & George, 2007), respectively. Nutritional status was assessed with the Mini-Nutritional Assessment Instrument (MNA) (Saka, Kaya, Ozturk, Erten, & Karan, 2010).

Sitting time. Sitting time was assessed using a single-item question from the International Physical Activity Questionnaire (IPAQ) Short Form. Participants were asked, "during the last 7 days, how much time did you usually spend sitting on a week day?" Participants were instructed to include all time spent in-facility leisure and social activities, and lying down. The standard IPAQ measure has shown to have moderate reliability with older adults (Tomioka, Iwamoto, Saeki, & Okamoto, 2011).

Sarcopenia. Sarcopenia was measured using the EWGSOP definition, cut-off points and assessment criteria (Cruz-Jentoft et al., 2010). *Muscle mass* was estimated using BIA (Maltron BF-906, Maltron International Ltd, Rayleigh, UK), with the participant requested to lie flat on a bed while electrodes were placed on the wrist and feet in standardized positions.

Skeletal Muscle Mass (SMM) was calculated from the equation (SMM = [(height^2(cm) /resistance (ohms) x 0.401) + (gender x 3.825) + (age (yrs) x -0.071)] + 5.102), with this value then divided by height^2 (m) to provide the Skeletal Muscle Index (SMI)(Janssen, Heymsfield, Baumgartner, & Ross, 2000). The SMI cut-off of <8.87 kg/m^2 and <6.42kg/m^2 were used to define low muscle mass in older men and women, respectively. *Muscle strength* was measured by Jamar hand grip dynamometer (Sammons Preston Roylan, Bolingbrook, IL), whereby the participants were asked to squeeze the dynamometer as hard as they could with their dominant hand while their elbow was bent to 90^0 and locked at their side. The best of three trials was used to quantify handgrip strength and cut-off points of < 30 and < 20 kg were used to define low muscle strength for men and women, respectively. *Physical performance* was measured by the 2.4-meter walk test from the Short Physical Performance Battery (described below). The best of three trials was retained for data analysis, with gait speeds < 0.8 m/s used to define low physical performance in older males and females.

Short Physical Performance Battery. The Short Physical Performance Battery (SPPB) summary score was used to determine overall physical function. This is a valid and reliable measure of physical function and incorporates three tasks reflective of daily activities: a progressive static balance measure, habitual gait speed, and sit-to-stand performance. Tasks are scored individually and a summary score (ranging from 0-12) is generated.

Statistical Analysis

All analyses were performed using the open source software R, version 3.0.2 (R Development Core Team, 2013). Descriptive statistics are presented as means and standard deviations (SD) for normally distributed data, median (25th, 75th percentile) for non-normal continuous data, or percentages for categorical data. Cross-sectional analyses were performed on the baseline sample (n=102), while longitudinal models were performed with participants

with data at baseline and follow-up (n=58). Three models were assessed: model 1 was unadjusted; model 2 adjusted for age and sex; model 3 additionally adjusted for being physical active now (yes vs no), nutritional status and BMI. Covariates are based on baseline measures. Associations between sitting time and sarcopenia status at baseline and change in sarcopenia status were assessed using logistic regression controlling for these demographic and health factors. Linear models were included to quantify the association of sitting time with the SPPB summary score, and change in this score from baseline to follow up. Model diagnostics were completed for each test to assess model assumptions and identify data points with large influence on parameter estimates. No concerns were raised for model assumptions; however, logistic regression analyses revealed a small number of data points with high influence and therefore sensitivity analyses were conducted in these cases.

Results

Demographic and health data from 102 participants at baseline and 58 participants at follow-up were available for analysis. Of those eligible at follow-up (n=75), 77% agreed to participate (n=58). At follow-up, participants were aged 85.6 ± 8.2 years with an average BMI of 26.9 ± 5.7 kg/m2, 70.7% were female and 41.4% had experienced a fall in the previous 6 months (Table 1). At baseline, participants reported sitting for 12.9 ± 3.0 hours each day, while 39 (39.8%) of participants reported being physical active at the time of the baseline interview. A total of 40% of participants were sarcopenic at baseline, increasing to 64.3% at follow-up. The average SPPB summary score decreased by one point from baseline (mean ± SD = 3.5 ± 2.4) to follow-up (2.5 ± 2.2) (Table 2).

Associations of sitting time with baseline and follow-up sarcopenia status

Table 3 shows the cross-sectional association of sitting time with sarcopenia status. Each hour of sitting was associated with approximately 16% increased odds ratio of being

sarcopenic in the unadjusted model. However, associations did not reach statistical significance (p>0.05; see Table 3). Diagnostic plots of residuals and calculation of Cook's distance identified two observations that exerted a large influence on parameter estimates (Cook's distance ≥ .068). Sensitivity analyses conducted with removal of these points increased the odds ratio for sitting time, with significant values obtained for the unadjusted (OR =1.20; 95% CI: 1.02 - 1.45) and age and gender adjusted (OR =1.21; 95% CI: 1.02 - 1.47) models, but not the fully adjusted model (OR =1.14; 95% CI: 0.97 - 1.43).

Only a small number of individuals that were non-sarcopenic at baseline provided follow-up data on sarcopenia status. Therefore, an unadjusted logistic regression analysis comparing participants who remained sarcopenia free (n=15) with those that developed sarcopenia over the 18-month period (n=8) was conducted. This analysis did not observe a statistically significant association of sitting time with change in sarcopenia status (OR = 0.91; 95% CI: 0.64 - 1.26).

Association of sitting time with baseline and follow-up physical performance

Table 3 also shows the cross-sectional association of sitting time with the SPPB. At baseline, sitting time was observed to be detrimentally associated with the SPPB summary score in all models (n = 102; see Table 3). In contrast, SPPB summary scores for those completing pre- and post-tests (n=58) demonstrated a mean decrease of 0.91-points (± 1.69). Associations of baseline sitting with change in the SPPB summary score were not statistically significant (Table 4).

Discussion

This 18-month follow up study in RAC residents aimed to investigate cross-sectional and longitudinal associations of sitting time with sarcopenia and physical performance. Each hour of sitting time per day was found to be significantly associated with higher odds of being

sarcopenic (when outliers were removed) and lower overall function (measured by the SPPB). This is the first study to investigate if sitting time is associated with changes in sarcopenia status and physical performance over a follow-up period in RAC. The current study however found no statistically significant associations for the changes in sarcopenia or performance.

The cross-sectional finding that sitting time is likely associated with increased risk of having sarcopenia is consistent with findings from a small number of previous studies. A study of 1286 elderly UK men recruited from primary care settings also observed similar effect sizes, where each additional 30 minutes of sitting was associated with an 18% increased likelihood of having sarcopenia (Aggio et al., 2016), although this was not statistically significant. Others have observed sitting time to significantly increase the odds of having sarcopenia by 33% in community-dwelling older adults (Gianoudis, Bailey, & Daly, 2014). This emerging research suggests that sitting time is associated with an increased risk of sarcopenia. The findings of this study build on previous research that has observed a potential association in the long-term care setting. Larger scale studies are needed to further examine these preliminary findings.

The examination of sitting time and its health outcomes in RAC is an emerging field with few previous studies. However, the significant and detrimental association of sitting time with physical performance observed in this study is consistent with previous available data. One study in 19 institutionalised women found that sitting time was significantly associated with a number of functional tests, including timed up-and-go performance, lower-limb strength, balance and walking speed (Ikezoe et al., 2013). While exercise interventions have been shown to improve muscle strength and physical performance (Cruz-Jentoft et al., 2014), future research is needed to ascertain if function more broadly can be improved by reducing sitting time and replacing it with low intensity physical activity (e.g., standing or light walking) (de Souto Barreto, 2015) . A small pilot study in 26 participants in long-term care facilities showed that an intervention to break up sitting (i.e., encouraging residents to stand up and sit

down as many times as they could, twice per day) significantly improved their functional fitness (Slaughter et al., 2015). Sedentary time interventions may be less effective than structured resistance and balance exercise; however, they may be easier to adopt and maintain in the long-term whilst still providing some benefit**.** In addition, targeting sedentary behaviour could be used as a gateway into structured exercise programs or as an adjust intervention strategy. These preliminary results and potential uses need further exploration with larger and more diverse samples.

This was the first study to investigate sitting time as a risk factor for sarcopenia and decline in physical performance in the community and RAC setting over a follow-up period. Here, statistically significant associations were not observed with either sarcopenia status or performance, nor were effect sizes considered clinically meaningful. Few participants that were non-sarcopenic at baseline provided follow-up data. Given the low baseline SPPB scores, further declines were limited. Declines in function often accelerate in older age and in aged care (Jerez-Roig, de Brito Macedo Ferreira, Torres de Araujo, & Costa Lima, 2017; Peeters, Dobson, Deeg, & Brown, 2013), which may have already occurred in this sample. Nevertheless, there is reason to suspect that lifetime physical activity and sedentary behaviours may influence the trajectory of function decline for aged care residents. Studies have shown that, at least for exercise, early life interventions are best at maintaining functional capacity into older age (Peeters et al., 2013). In addition, a study examining trajectories of habitual television-viewing time (as an estimate of total sedentary behaviour) observed that increasing TV viewing time is associated with poorer lower-limb muscle strength after 12 years, compared with those that maintain low levels of TV viewing (Reid et al., 2017). More prospective studies are needed to examine the impact of sedentary behaviour on various measures of function over time.

A key strength of this study is the investigation of an understudied population and use of the EWGSOP definition of sarcopenia. While it has been shown that older adults often under report their sitting time (Van Cauwenberg, Van Holle, De Baurdeaudhuij, Owen, & Deforche, 2014); the IPAQ self-reported sitting time of 12.9 hours at baseline is similar to objectively-assessed sitting time in a sub-sample of this dataset (mean sitting = 12.4 hrs/day) (Reid et al., 2013). Given that average length of stay in Australian RAC is less than 3 years (Australian institute of Health and Welfare, 2016), the follow-up period of 18-months was sufficient. Limitations of this study include a small sample size, with the cross-sectional findings precluding the ability to infer causality. Findings are not generalizable beyond the scope of the participant characteristics in this study.

Conclusions

This was one of the first studies to investigate the cross-sectional and prospective association of sitting time with sarcopenia and physical performance in Australian RAC centres. A detrimental association of sitting time was observed with sarcopenia and performance at baseline. No association was observed with risk of developing sarcopenia or decline in physical performance. However, prospective studies that capture people at their initial entry into the RAC setting would more accurately capture changes in health outcomes in this population. Future studies may benefit from the use of objective monitors in measuring sitting time and investigating the possibility of reverse causation (i.e., that low function leads to higher sitting time). Intervention studies targeted at reducing sitting time and replacing it with higher intensity activities are also needed to determine if this can improve physical function in RAC residents. Lastly, there is a need for physicians, nurses and allied health professionals in the community and nursing home settings to be educated on the negative health impacts of sitting time on the physical function of older adults.

Funding

This study was supported by the Faculty of Health Sciences and Medicine, Bond University Seeding Grant (grant # 122R4; for TR and JK), the Australian Postgraduate Award Scholarship (for NR) and National Health and Medical Research Council of Australia and Australian Research Council Dementia Research Development Fellowship #110331 (for PG).

Acknowledgments

We would like to thank all XXX nursing home residents and staff who volunteered their time for this study. We also thank our Research Assistant, XXX, who contributed to recruitment and assessments at baseline, and XXX for her collection of the follow-up data.

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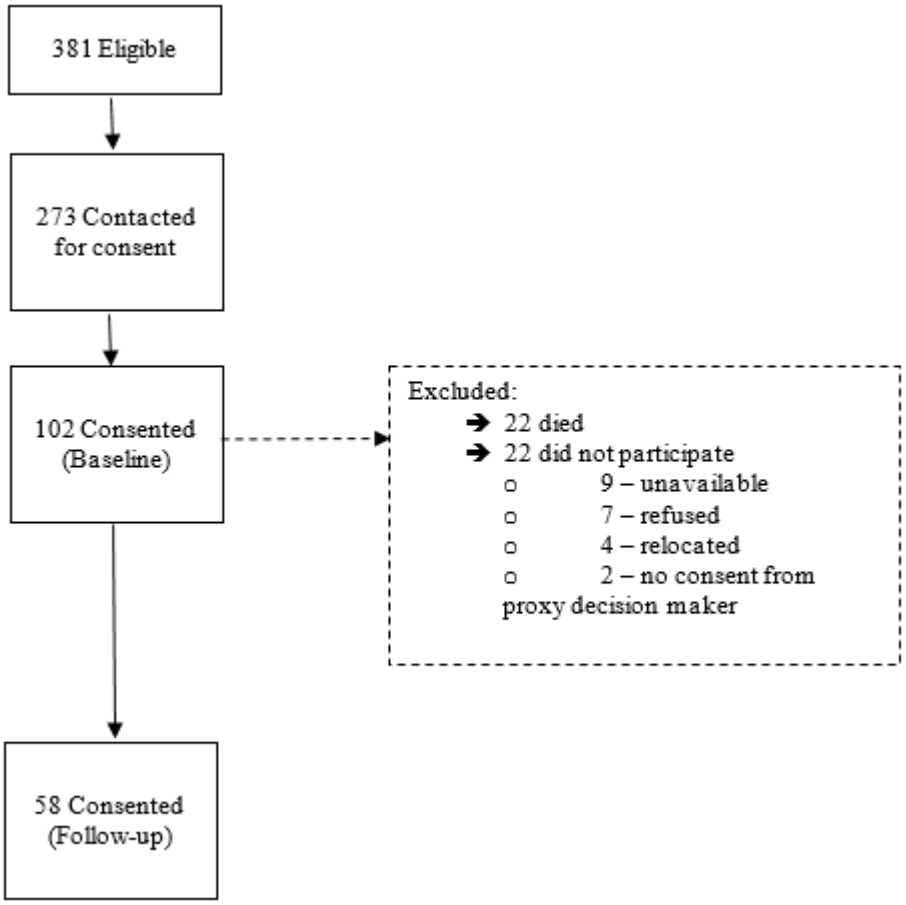

Figure 1: Recruitment flowchart

Table 1. Demographic and health data at baseline (n=102) and 18-month follow-up (n=58) of RAC residents.

Characteristic	Baseline (n=102)	Follow-up (n=58)
Age, years	84.5 ± 8.2	85.6 ± 8.2
Female, n (%)	71 (69.6)	41 (70.7)
Current smoker, n (%)	10 (10.2)	-
Falls in past 6 months, n (%)	27 (26.4)	24 (41.4)
BMI, $kg.m^{-2}$	27.0 ± 5.7	26.9 ± 6.2
MMSE	20.9 ± 6.4	16.7 ± 9.3
Severe, n (%)	4 (4.3)	16 (27.6)
Moderate, n (%)	40 (41.7)	16 (27.6)
Mild, n (%)	16 (16.7)	8 (13.8)
Normal, n (%)	36 (37.5)	18 (31.0)
GDS	5.2 ± 3.8	4.6 ± 3.8
Severe, n (%)	9 (9.4)	5 (8.5)
Moderate, n (%)	13 (13.5)	6 (10.2)
Mild, n (%)	22 (22.9)	16 (27.1)
Normal, n (%)	52 (54.2)	31 (52.5)
MNA	10.5 ± 2.5	8.2 ± 3.1
Malnourished, n (%)	15 (14.7)	20 (34.5)
At risk, n (%)	49 (48.0)	30 (51.7)
Normal, n (%)	37 (36.3)	8 (13.8)

Values represent mean ± SD or number (percentage) unless indicated. BMI = body mass index; MMSE = mini-mental state exam; GDS = Geriatric depression scale; MNA = mini-nutritional assessment; SPPB = short physical performance battery.

Table 2. Activity and physical performance measures at baseline (n=102) and 18-month follow-up (n=58) of RAC residents.

Measure	Baseline (n=102)	Follow-up (n=58)
Sitting time, hours/day [a]	12.9 ± 3.0	-
Physically active now, n (%) [a]	39 (39.8)	-
Sarcopenic, n (%)	41 (40.2)	30 (64.3) [b]
Skeletal muscle index, kg/m^2	7.7 ± 2.3	7.2 ± 1.8 [b]
Grip strength, kg	16.5 ± 7.7	12.7 ± 7.6
SPPB summary [c] [Median (25th, 75th)]	3.5 ± 2.4 [3 (2, 5)]	2.5 ± 2.2 [1 (1, 3)]
Standing balance, sec	13.9 ± 10.0	6.9 ± 10.2
Gait speed, m/s	0.4 ± 0.2	0.2 ± 0.2
5 chair stands, s [d]	20.9 ± 5.4	23.2 ± 12.46

Results are presented as mean ± standard deviation (SD), unless otherwise stated.

[a] reported baseline only. [b] based on 42 participants with available data. [c] SPPB summary score was positively skewed, both mean ± SD and median (interquartile range) are presented. [d] a number of participants scored zero on this test, indicating they could not complete it. Mean and SD are representative of participants who could complete the test (n = 27 at baseline, n = 13 at follow-up).

Table 3. Cross-sectional associations of baseline sitting time with sarcopenia and SPPB score in RAC residents (n = 102)

Sarcopenia	Odds Ratio (95% CI)	p-value
Model 1 (unadjusted)	1.16 (0.98, 1.37)	0.08
Model 2	1.17 (0.99, 1.38)	0.07
Model 3	1.17 (0.96, 1.42)	0.12
SPPB	β Coefficient (95% CI)	p-value
Model 1 (unadjusted)	-0.30 (-0.47, -0.13)	< 0.001
Model 2	-0.29 (-0.46, -0.12)	0.001
Model 3	-0.20 (-0.37, -0.03)	0.027

All covariates are based on baseline measures. Model 2 adjusted for age and sex; Model 3 additionally adjusted for being physical active now (yes vs no), nutritional status and BMI.

Table 4. Association of baseline sitting time with change in SPPB score in RAC residents (n = 58).

Change in SPPB	β Coefficient (95% CI)	p-value
Model 1 (unadjusted)	0.15 (-0.03, 0.32)	0.109
Model 2	0.15 (-0.04, 0.33)	0.132
Model 3	0.14 (-0.07, 0.35)	0.183

All covariates are based on baseline measures. Model 2 adjusted for age and sex; Model 3 additionally adjusted for being physical active now (yes vs no), nutritional status and BMI.