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Breaking-up sedentary time is associated with impairment in activities of daily living

Luis B. Sardinha[1], Ulf Ekelund[2,3], Leandro dos Santos[4], Edilson S. Cyrino[4], Analiza M. Silva[1], Diana A. Santos[1]

[1]Exercise and Health Laboratory, CIPER, Faculdade de Motricidade Humana, Universidade de Lisboa, Portugal
[2] Department of Sport Medicine, Norwegian School of Sport Sciences, Oslo, Norway
[3] MRC Epidemiology Unit, Institute of Metabolic Science, Addenbrooke's Hospital Hills Road, University of Cambridge, UK;

[4]Study and Research Group in Metabolism, Nutrition, and Exercise GEPEMENE, State University of Londrina - UEL, Londrina, Brazil.

Corresponding Author:
Luís B. Sardinha, Faculdade de Motricidade Humana, Estrada da Costa, 1499-002 Cruz-Quebrada, +351 21 414 91 60 (telephone); (+351) 21 414 91 93 (fax); Email: lsardinha@fmh.ulisboa.pt

Abstract

Identifying modifiable behaviours associated with prevention of activities of daily living (ADL) impairments is vital to implement preventive strategies for independent living in elderly. We aimed to examine the associations between objectively measured breaks in sedentary time with ADL impairments and physical independence. Cross-sectional assessments were carried out in 371 participants (131 male) aged 65-103 years from the Portuguese surveillance system of physical activity. Physical Activity (PA) and sedentary time (ST) were assessed with accelerometry, and ADL impairments and physical independence with the self-reported 12-item composite physical function scale. Using ROC analyses a cut-off of 7 hourly breaks in sedentary time was identified which maximized the sensitivity and specificity in diagnosing physical dependence. Logistic regression analysis demonstrated that, independently of moderate-to-vigorous PA (MVPA), participants performing $\leq$7 hourly breaks in sedentary time had 2 to 7 fold increased odds for impairment in 10 of the 12 ADL. When stratifying ADL into basic, instrumental and advanced ADL we verified that less than 7 hourly breaks in sedentary time was associated ($p<0.05$) with a 2 to 5 fold increased odds for impairments and physical dependence, independent of MVPA. No associations ($p>0.05$) were observed between meeting PA guidelines and basic, instrumental, and advanced ADL impairment although time in MVPA was lower ($p<0.05$) in participants showing impairments. In conclusion, the frequency of breaks in sedentary time in older ages is independently associated with lower risk for ADL impairments and physical dependence. Our findings support interventions to encourage older adults to increase overall PA by interrupting sedentary time.

Keywords: breaks in sedentary time; sedentary time; physical activity; ADL impairment, physical independence.

1. Introduction

Older adults are at increased risk of functional decline, which may progress into functional limitations and eventually to impairment and physical dependence (Wang and others 2002). Impairment in activities of daily living (ADL), such as tasks essential to household management and tasks of basic self-care often occur in community-dwelling older adults (Fried and others 2004). Considerable public health benefits would arise if the onset of disability could be delayed (or eliminated) as physical impairment and frailty are associated with increased need of personal care and substantial societal costs (Field and Jette 2007; Wolff and others 2002)

High amounts of sedentary time (ST) appears associated with the metabolic syndrome (Gardiner and others 2011), fatness (Inoue and others 2012), physical function (Chastin and others 2012; Davis and others 2014; McDermott and others 2011; Santos and others 2012), and impairment in ADL (Blodgett and others 2015; Dunlop and others 2014; Gennuso and others 2013) independent of time spent in moderate-to-vigorous intensity physical activity (MVPA). Further, patterns of sedentary time may also influence selected health outcomes (Owen 2012), apart from the total time spent sedentary, breaking-up sedentary time appears associated with lower extremity function (Davis and others 2014) and with overall physical function in older adults (Sardinha and others 2014). Further, the likelihood of being characterized with the metabolic syndrome in individuals aged ≥60 years old is significantly increased in those who accumulate sedentary time in more prolonged bouts compared to individuals who accumulate sedentary time in shorter bouts (i.e., more breaks or interruptions to sedentary time, where activity levels reach at least light intensity) (Bankoski and others 2011). However, it is unknown whether breaking-up sedentary time is associated with impairments in activities of daily living.

It has been previously reported that the number of breaks in sedentary time (BST) decreases with age (Jefferis and others 2014; Shiroma and others 2013), and prolonged sedentary time results in less muscular contractions throughout the day (Hamilton and others 2007). Taken together, these observations suggest that we are facing a paradigm shift in understanding functional decline and disability, and preventive strategies aimed at breaking-up sedentary time may be relevant to improve functional healthy aging.

The role of breaking-up sedentary time in physical independence and on the ability to perform selected ADL requires further clarification. Thus, the aim of this study to examine the associations between the frequency of breaks in sedentary time with physical independence and impairment in ADL in a large population based cohort of older Portuguese adults in which physical activity and sedentary time were measured objectively.

2. Material and Methods

2.1. Design and Subjects

The current study included a sample of noninstitutionalized Portuguese older adults, aged between 65 and 103 years, selected by means of a proportionate stratified random sampling taking into account the number of people by age and sex in each region of mainland Portugal, according to the NUTS II subregions: Territorial Units for Statistics Portugal. Sample recruitment was carried out in senior universities, parish councils, city halls, day care centers, and health promotion fairs. Organizers were contacted by email and/or formal letter informing about the objectives of our study. Eligibility criteria included: (1) ≥ 65 years of age; (2) ability to comprehend Portuguese; (3) ambulatory or ambulatory with assistance (not institutionalized, bedridden, or homebound); and (4) ability to comprehend and sign the informed consent.

A total of 407 participants were assessed for physical independence, physical activity and sedentary time, for the present analyses, a total of 371 participants with valid data were included (131 males and 240 females). All participants were informed about the possible risks of the investigation and gave their written informed consent. All procedures were approved by the local ethics Committee and were conducted in accordance with the Declaration of Helsinki for human studies.

2.2.Outcome measures

2.2.1. Physical Activity and Sedentary Time

Physical Activity (PA) and sedentary time were assessed by accelerometry (ActiGraph, GT1M, Fort Walton Beach, FL). All participants were asked to wear the accelerometer on the right hip, near the iliac crest for four consecutive days, including 2 weekdays and 2 weekend days. Participants received a diary to record

the time of the day when the accelerometer was attached and removed. The devices were activated on the morning of the first day and data were recorded in 15-s epochs. However, all analyses were conducted with data transformed into 60-s epochs to allow comparison with other studies. Apart from accelerometer non-wear time (i.e., when it was removed for sleeping or water activities), periods of at least 60 consecutive minutes of zero activity intensity counts were also considered as non-wear time. A valid day was defined as having 600 minutes (10 hours) or more of monitor wear, and the study included the results from participants with at least three valid days (including one weekend day). Considering these criteria a total of 36 participants (8.8 % of the sample) were excluded from the analysis. No differences in the proportion of males and females, age, and BMI between those included and those excluded from the analysis were observed.

Each minute during which the accelerometer counts were below 100 counts/min was defined as sedentary time. A break in sedentary time was defined as all interruptions (lasting at least 1-minute) in sedentary time when the recorded counts value were > 100 counts/min (Sardinha and others 2014). BST were divided by total sedentary time and the variable hourly breaks in sedentary time (BST/ST) was used in analysis.

Accelerometer counts ≥100 counts/min were classified as physical activity with additional separation into light-intensity (LIPA: 100–2,019 counts/min) and moderate-to-vigorous intensity (MVPA: ≥2,020 counts/min) (Baptista and others 2012; Troiano and others 2008). The intensity threshold for MVPA was has previously been established to be used in adults and older adults, as a weighted average of thresholds determined from different studies based on treadmill or track-walking activities, equivalent to 3 METs (moderate intensity). Light physical activity was then defined as time above any period that was not spent sedentary (<100 counts/min) and below moderate intensity (<2020 counts/min) (Troiano and others 2008). The Actilife software (version 6.0, ActiGraph, Fort Walton Beach, FL) was used for data reduction. Compliance with physical activity recommendations for public health was assessed by examining the prevalence of individuals accumulating at least 30 min/d of MVPA.

2.2.2. Physical Independence and ADL impairment

Physical independence was assessed through self-report using the 12-item composite physical function (CPF) scale. The CPF scale describes a wide range of functional abilities, from those associated with basic, to instrumental or intermediate to advanced ADL. The scoring requires that participants check one of three

responses associated with each of the 12-items: can do (score=2), can do with help (score=1), or cannot do (score=0). Scores are thereafter summed with a potential range of scores between 0 and 24 (Rikli and Jones 1998; Rikli and Jones 2013). The age-adjusted scoring option for defining moderate functioning that reflects projected ability for physical independence at age 90 years, rather than current ability to function independently, as previously proposed, was used. Using the age adjusting scoring a moderate to high functioning is defined as follows; 90+ years: ≥ 14 (able to perform at least seven activities without assistance); 80-89 yrs: ≥16 (able to perform at least eight activities without help); 70-79 yrs: ≥18 (able to perform at least nine activities without help); and 65-69 yrs: ≥ 20 (able to perform at least 10 activities without help) (Rikli and Jones 2013). Accordingly, physical independence was dichotomized as: low functioning (high risk) and moderate to high functioning (low risk). The use of the age-adjusted option allows for the early detection of risk for loss of mobility and independence prior to age 90 years in those in their 60s, 70s, and 80s (Rikli and Jones 2013).

Furthermore, questions have been grouped into basic activities of daily living (BADL) comprising the following items: ability to "take care of own personal need" and "bathe yourself using tub or shower"; instrumental activities of daily living (IADL) comprising the items: ability to "climb up and down a flight of stairs", "walk outside (1 – 2 blocks)", "do light household chores (like cooking. dusting. etc.)", "do own shopping/errands (walk 3 - 4 blocks)", "walk 1/2 mile (6 – 7 blocks)", "walk 1 mile (12 – 14 blocks)", "lift and carry 10 pounds (bag of groceries)", and "lift and carry 25 pounds (medium to large suitcase)"; and advanced activities of daily living (AADL) comprising the items: ability to "do heavy household activities — like scrubbing floors, etc." and "do strenuous activities — like hiking, digging in garden, etc." (Rikli and Jones 2013). Impairment (risk category) in one BADL, IADL, and AADL was considered if participants reported that were unable to perform that activity ("cannot do" or "can do with help"), and impairment in BADL, IADL, and AADL was defined if participants reported impairment in at least one BADL, IADL, or AADL, respectively (defined as the high risk category respectively for BADL, ADL, and IADL).

The single-trial intraclass test-retest reliability estimate for this scale was reported to be 0.94, computed on scores obtained 2 to 4 weeks apart. Scores of the CPF scale were highly correlated (r: 0.92-0.96) with other validated scales (convergent validity), and discriminatively validity has been demonstrated (Rikli and Jones 1998).

2.2.3. Covariates

Participants were weighed to the nearest 0.1 kg wearing minimal clothes and without shoes. Height was measured to the nearest 0.1 cm. Body mass index was calculated as weight (kg) divided by the square of the height (m). Self-reported educational and medical covariates were assessed via interviewer-administered questionnaires. Educational attainment was categorized as: (a) no formal education, (b) 4 years of education, (c) 9 years of education, (d) 12 years of education, and (e) higher education. Medical history for hypertension, elevated cholesterol and glycaemia, current medication, and the presence of any long-standing condition such as diabetes, asthma, cancer, or cardiac disease and current smoking status were also reported and classified in two categories (no or yes).

2.3. Statistical analysis

All analyses were performed with SPSS Statistics version 22.0, 2013 (SPSS Inc., Chicago, Illinois, U.S.A.). Descriptive statistics (mean ± SD) were calculated for all outcome measurements. Mean comparisons between independent groups were performed using independent sample T-test or the Mann-Whitney test. To compare frequencies between groups the Chi-square test was used. Receiver Operating Characteristic (ROC) analyses were performed to determine the cutoff for hourly breaks in sedentary time that maximized the sum of sensitivity and specificity in diagnosing projected ability for physical independence. Additionally ROC analyses were conducted to examine the sensitivity and specificity of this cutoff in diagnosing the ability to perform selected basic, instrumental, and advanced ADL. Logistic regression analysis was conducted to examine the association between hourly breaks in sedentary time and compliance with public health guidelines for physical activity (i.e. accumulation of > 30 min of MVPA / day) with projected ability for physical independence and with selected basic, instrumental, and ADL. Analysis were adjusted for age, sex, BMI, MVPA (when hourly breaks in sedentary time was the independent variable), education, medical history for chronic disease, hypertension, elevated cholesterol or glycaemia, smoking status, and current medication status. For all tests significance was set at $p<0.05$.

3. Results

Participants' characteristics are summarized in table 1.

TABLE 1

ROC analysis were performed to determine the cutoff for hourly breaks in sedentary time that maximized the sum of sensitivity and specificity for diagnosing older adults that were not at risk for physical dependence (table 2).

TABLE 2

The area under the ROC curve (AUC) was 0.67 and the cutoff ≥ 7 hourly breaks in sedentary time maximized the sum of sensitivity (0.52) and specificity (0.78). This cutoff was applied to each item and to the ability to perform ADL (basic, instrumental, and advanced). With the exception of the ability to "lift and carry 25 pounds", hourly breaks in sedentary time were able to diagnose all items with AUC ranging from 0.70 to 0.80 for basic, 0.58 to 0.76 for instrumental, and from 0.59 to 0.62 for advanced ADL. Overall, the sensitivity of the ≥7 hourly breaks in sedentary time was lower (0.37-0.77) than specificity (0.55-0.80).

Logistic regression analyses were thereafter performed to analyze the association between breaks in sedentary time and the ADL (basic, instrumental, and advanced ADL) (Table 3).

TABLE 3

Significant associations were observed between breaks in sedentary time and ADL impairments, except for the ability to "walk 1-mile" and "lift and carry 25 pounds". The results remained similar after adjusting for MVPA and other covariates (Models 2 and 3). This means that participants performing less ≤ 7 hourly breaks were more likely to report "cannot do" or "can do with help" to each ADL item.

Logistic regression analysis examining the associations between breaks in sedentary time, MVPA and ADL are illustrated in Fig. 1.

FIG. 1

Overall, participants with less than 7 breaks per hour were at increased risk of being unable to perform ADL [basic: OR=5.24 (95% CI= 2.35-11.72), advanced: OR=2.11 (95% CI= 1.08-4.03)], and at increased risk for physical dependence [OR=2.97 (95% CI= 1.52-5.81)] independent of time spent in MVPA and other covariates. As illustrated in Fig. 1, when analyzing the association between compliance with physical activity guidelines (MVPA ≥ 30 min/d) significant associations were found with activities of daily living (basic, instrumental, and advanced), and physical independence.

We additionally analyzed participants' hourly breaks in sedentary time and MVPA by low and high risk categories for impairment in basic, instrumental, and advanced ADL, and physical independence and observed that participants in the high risk categories were less physically active as indicated by lower frequency of breaks in sedentary time and in accumulated time in MVPA, comparing to the low risk groups (Fig. 2).

FIG. 2

4. Discussion

The objective of this study was to analyze the role of breaking-up sedentary time in projected ability for physical independence and impairment in activities of daily living in non-instutionalized adults aged 65 years and older. Our results suggested that the frequency of interruptions of sedentary time, but not time spent in MVPA, was associated with impairments in activities of daily living and projected ability for physical independence. This suggest that future interventions aimed at improving physical independence in the elderly may benefit from increasing overall physical activity by frequent breaks in sedentary time rather than participation in activities of moderate and higher intensity.

Older adults may spend up to 80% of their waking hours in sedentary time and recent evidence has highlighted the harmful health effects of high amounts of sedentary time in relation to various health outcomes (Gardiner

and others 2011; Inoue and others 2012), including physical function (Chastin and others 2012; Davis and others 2014; McDermott and others 2011; Santos and others 2012). More recently, the role of breaking-up sedentary time in relation to physical function, assessed by physical fitness tests, has been identified (Davis and others 2014; Sardinha and others 2014), but the impact of breaking-up sedentary time in relation to impairments in ADL has not been investigated.

Using data from the NHANES it was recently observed that impairments in ADL was associated with increased time accumulated sedentary (Dunlop and others 2014). The results suggested that for each additional hour of sedentary time the odds for ADL impairment increased by 50%, independent of the amount of time spent in MVPA. Blodgett et al. (Blodgett and others 2015) also observed that older adults spending larger amounts of time sedentary were more likely to be frail and that sedentary time was associated with higher odds for impairments in ADL, independent of time spent in MVPA. Similarly, Gennuso and others (2013) concluded that MVPA and total sedentary time were independently associated with impairment in selected ADL. Frequency of breaks in sedentary time, appears associated with physical function (Davis and others 2014; Sardinha and others 2014) independent of time spent in MVPA, but a minimal number of hourly breaks in sedentary time has not been identified.

In this study we identified participants at risk of physical dependence by ROC analysis. A cutoff of ≤ 7 hourly breaks in sedentary time presented a sensitivity of 52% and a specificity of 78% in identifying participants at risk for losing physical independence later in life. A break in sedentary time, as assessed by accelerometers, reflects a change in acceleration rather than a change in posture, corresponding to a transition from none or little movement to some movement (Barreira and others 2015; Judice and others 2015). A break in sedentary time does not necessarily correspond to a transition from a sitting to a standing position, it can be a change from a standing position to walking. However, it is important to note that a cutoff of 7 hourly breaks in sedentary time is an achievable target by the majority of the population, considering that the mean hourly breaks observed in our sample was 9.0 (ranging from 1 to 19 hourly breaks). The 7 hourly breaks in sedentary time cutoff presented a relatively low sensitivity, which represents the percentage of physically dependent older adults who were correctly identified as having the condition. Regardless, when using this cutoff in the logistic analysis we observed that older adults who performed less than 7 hourly breaks in sedentary time were at risk for ADL impairment and physical dependence. A better balance between true positive and true negative rate was found

when using the 7 hourly breaks in sedentary time cutoff to identify impairment in basic ADL. Basic ADL includes the ability to "take care of own personal need" and "bathe yourself using tub or shower", which are determinant for being able to live independently (Rikli and Jones 2013) and are associated with mortality and incident impairment (Abizanda and others 2014).

An interesting finding of the present study was that meeting the 30 min per day of MVPA guideline was not associated with lower scores of impairment in basic, instrumental, and advanced ADL or with projected ability for physical independence. Dunlop and others (2014) have recently observed that, when also considering time in sedentary time, MVPA was not associated with ADL impairment. Our results complement these findings by observing that breaking-up sedentary time but not complying with MVPA guidelines was associated with impairment in basic ADL and instrumental ADL, and with projected ability for losing physical independence. Regardless, it is important to highlight that participants that were at risk for impairment in basic, instrumental, and advanced ADL had lower values for both the frequency of breaks in sedentary time and MVPA, comparing to the low risk categories. These results emphasize the impact of total physical activity of the ability to perform ADL. It is important to mention that when older adults are not able to accomplish the recommended amounts of physical activity due to health conditions, they should be as physically active as their abilities and conditions allow (WHO 2010), and therefore, even smaller amounts of physical activity may result in health benefits. Regarding sedentary time and the frequency of breaks in sedentary time, to date there are no numerical recommendations, regardless guidelines for older adults highlight that persons who do less activity than recommended still achieve some health benefits by reducing their sedentary time (Nelson and others 2007).

Strengths and limitations

An important strength of our study is that sedentary time was objectively measured by accelerometry. However, accelerometry is associated with some limitations as the method is not sensitive to detect all activities such as biking, or upper body movement. The cross-sectional design of this study limits inference about the direction of causality between the hourly breaks in sedentary time and ADL impairment. In the present study the ability to retain independent functioning in later in life was predicted based on an anticipated decline in functional ability that is similar to the 10-15% reported rate of physiological decline per decade in older adults (Rikli and Jones 2013). However, our results should be confirmed using longitudinal observational data and randomized controlled trials.

5. Conclusions

Breaking-up sedentary time and thereby increase overall physical activity is associated with lower odds of impairments in activities of daily living, independent of the time spent in MVPA and other covariates in older adults. Breaking up sedentary time appears a feasible approach for those elderly who want to enhance their ability to perform activities of daily living.

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Table 1. Participants' Characteristics, according to projected ability for physical independence

Variable	All (n=371; 240 F, 131 M)	Low Risk (n=276; 163 F, 113 M)	High Risk (n=95; 77 F, 18 M)
Age (years)	74.7 ± 6.9	73.3 ± 6.3	78.7 ± 7.2[a]
Weight (kg)	68.4 ± 11.7	68.9 ± 11.5	67.1 ± 12.2
Height (m)	1.57 ± 0.1	1.59 ± 0.1	1.54 ± 0.1[a]
BMI (kg/m²)	27.6 ± 4.1	27.3 ± 3.7	28.5 ± 4.8
Sedentary time[b] (min.day^{-1})	539.7 ± 129.5	525.3 ± 125.5	581.7 ± 132.5[a]
Light PA (min.day^{-1})	265.3 ± 115.4	285.5 ± 106.6	206.9 ± 121.7[a]
MVPA	15.6 ± 22.5	17.8 ± 22.8	9.2 ± 20.6[a]
Sufficiently active (%)	17.0	19.6	9.5[a]
BST (number.day^{-1})	74.9 ± 20.0	78.0 ± 17.6	65.9 ± 23.6[a]
BST / SB (number.h^{-1})	9.0 ± 3.6	9.5 ± 3.3	7.5 ± 3.9[a]
Wear time (min.day^{-1})	823.4 ± 92.1	832.2 ± 94.4	798.1 ± 80.4
CPF score	19.4 ± 5.9	22.4 ± 2.1	10.8 ± 4.6[a]
Hypertensive (%)	49.3	48.9	50.5
Hypercholesterolemia or glycemia (%)	42.0	43.5	37.9
Medical history for chronic disease (%)	36.7	29.7	56.8[a]
Take medication (%)	90.3	89.1	93.7
Current smokers (%)	2.2	2.5	1.1

Abbreviations: F, female, M, male; BMI, body mass index; PA, physical activity; MVPA, moderate-to-vigorous physical activity; BST, breaks in sedentary time; BST / SB, breaks of sedentary time per hour of sedentary time hour; CPF, composite physical function.

[a]Significant differences between low and high risk groups ($p<0.05$).

[b]Adjusted for wear time

Table 2. Receiver operating characteristic analysis for breaks in sedentary time to diagnose the risk for losing physical independence and impairment to perform basic, instrumental, and advanced activities of daily living.

Variable	Area Under the Curve (95%IC)	Cutoff	Sensitivity	Specificity
Composite Physical Function	0.67 (0.60 – 0.74)*	7[a]	0.52	0.78
Take care of own personal need	0.70 (0.59 – 0.82)*	7[b]	0.58	0.72
Bathe yourself using tub or shower	0.80 (0.73 – 0.88)*	7[b]	0.77	0.77
Basic activities of daily living[c]	***0.79 (0.72 – 0.86)****	***7[b]***	***0.71***	***0.77***
Climb up and down a flight of stairs	0.63 (0.55 – 0.71)*	7[b]	0.51	0.76
Walk outside (1 – 2 blocks)	0.70 (0.62 – 0.78)*	7[b]	0.75	0.55
Do light household chores (like cooking. dusting. etc.)	0.77 (0.70 – 0.83)*	7[b]	0.64	0.79
Do own shopping/errands (walk 3 - 4 blocks)	0.76 (0.70 – 0.82)*	7[b]	0.62	0.80
Walk 1/2 mile (6 – 7 blocks)	0.69 (0.61 – 0.77)*	7[b]	0.56	0.76
Walk 1 mile (12 – 14 blocks)	0.67 (0.60 – 0.73)*	7[b]	0.51	0.78
Lift and carry 10 pounds (bag of groceries)	0.58 (0.51 – 0.65)*	7[b]	0.39	0.73
Lift and carry 25 pounds (medium to large suitcase)	0.56 (0.50 – 0.62)	7[b]	0.36	0.74
Instrumental activities of daily living[c]	***0.56 (0.51 – 0.62)****	***7[b]***	***0.36***	***0.76***
Do heavy household activities — like scrubbing. floors. etc.	0.62 (0.56 – 0.69)*	7[b]	0.43	0.79
Do strenuous activities — like hiking. digging in garden. etc.	0.59 (0.54 – 0.65)*	7[b]	0.37	0.80
Advanced activities of daily living[c]	***0.59 (0.53 – 0.65)****	***7[b]***	***0.36***	***0.79***

*Significant at $p<0.05$; [a]Best cutoff that maximized the sum of sensibility and specificity; [b]The best cutoff observed to diagnose projected composite physical function was used for each question; [c]Impairment in at least 1 activity of daily living.

Table 3. Logistic regression analysis for the association between breaks in sedentary time with impairment in basic, instrumental, and advanced activities of daily living (the ≤ 7 hourly breaks in sedentary time was used as the reference). Results are presented as odds-ratio (95% confident intervals).

	Model 1[a] OR (95% CI)	Model 2[a,b] OR (95% CI)	Model 3[a,b,c] OR (95% CI)
Take care of own personal needs—like dressing yourself	**2.97 (1.11 - 7.90)***	**3.05 (1.11 - 8.36)***	**3.06 (1.03 - 9.13)***
Bathe yourself, using tub or shower	**7.74 (3.41 - 17.61)***	**7.75 (3.31 - 18.12)***	**6.99 (2.84 - 17.17)***
Walk outside (1–2 blocks)	**2.41 (1.28 - 4.53)***	**2.49 (1.30 - 4.77)***	**2.22 (1.12 - 4.39)***
Do light household chores—like cooking, dusting, washing dishes, and sweeping a walkway	**2.44 (1.20 - 4.96)***	**2.40 (1.16 - 4.99)***	2.08 (0.96 - 4.52)
Climb up and down a flight of stairs	**4.58 (2.37 - 8.84)***	**5.12 (2.58 - 10.19)***	**4.35 (2.11 - 8.97)***
Do own shopping/errands (walk approximately 3–4 blocks; 400 yards)	**4.80 (2.43 - 9.47)***	**5.22 (2.57 - 10.61)***	**4.28 (2.02 - 9.07)***
Lift and carry 10 pounds (bag of groceries)	**2.72 (1.36 - 5.42)***	**2.71 (1.33 - 5.51)***	**2.39 (1.13 - 5.04)***
Walk 1/2 mile (6–7 blocks)	**2.81 (1.53 - 5.17)***	**2.62 (1.40 - 4.90)***	**2.46 (1.27 - 4.75)***
Walk 1 mile (12–14 blocks)	1.40 (0.75 - 2.59)	1.46 (0.77 - 2.75)	1.23 (0.62 - 2.47)
Lift and carry 25 pounds (medium to large suitcase)	1.38 (0.78 - 2.43)	1.59 (0.88 - 2.86)	1.43 (0.77 - 2.64)
Do heavy household activities—like scrubbing, floors, vacuuming, and raking leaves	**2.58 (1.46 - 4.55)***	**2.76 (1.54 - 4.97)***	**2.53 (1.37 - 4.69)***
Do strenuous activities—like hiking, digging in garden, moving heavy objects, bicycling, aerobic dance activities, strenuous calisthenics, etc.	**2.24 (1.23 - 4.09)***	**2.05 (1.11 - 3.81)***	**2.03 (1.03 - 3.98)***

*Significant at $p<0.05$; [a]adjusted sex, age, and body mass index (BMI); [b]adjusted for moderate-to-vigorous physical activity (MVPA); [c]adjusted for education, medical history for chronic disease, hypertension, elevated cholesterol or glycemia, smoking status, and current medication status;

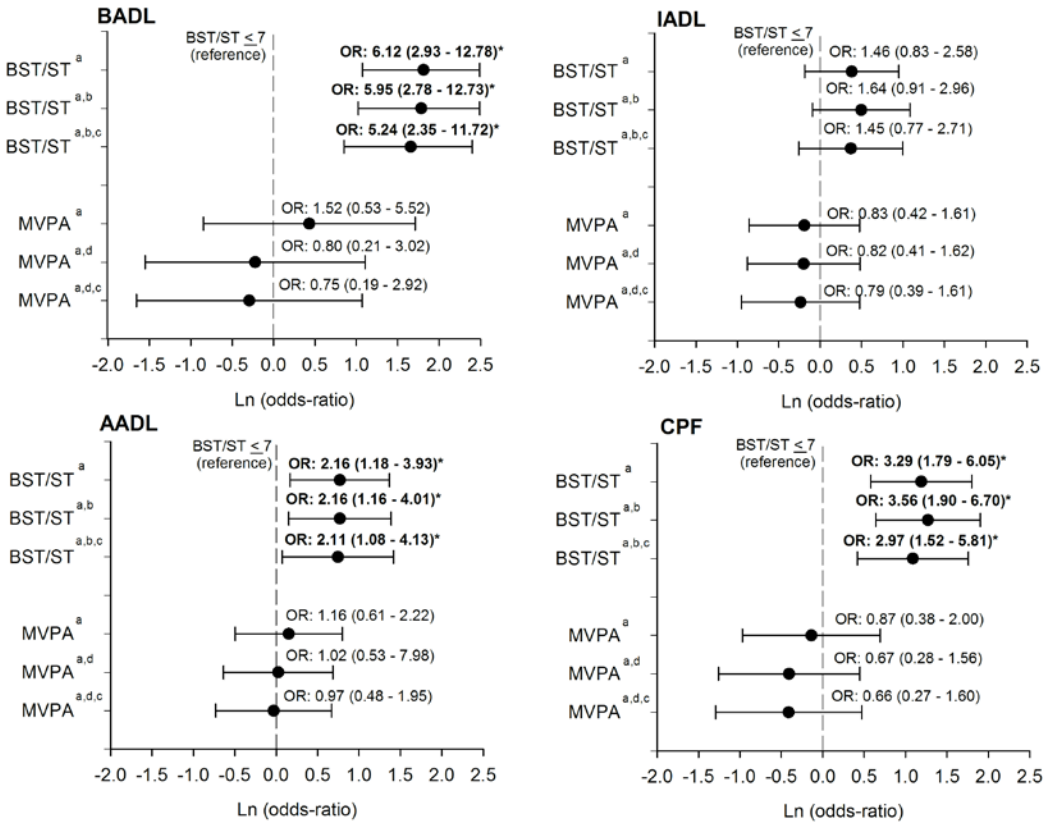

Fig. 1. Logistic regression analysis for the association between breaks in sedentary time with the risk of losing physical independence and impairment in basic, instrumental, and advanced activities of daily living.

*Significant at p<0.05; [a]adjusted for sex, age, and body mass index (BMI); [b]adjusted for moderate-to-vigorous physical activity (MVPA); [c]adjusted for education, medical history for chronic disease, hypertension, elevated cholesterol or glycemia, smoking status, and current medication status; [d]adjusted for number of breaks per hour of sedentary time (BST/ST)

Abbreviations: BADL, basic activities of daily live; IADL, instrumental activities of daily live; AADL, advanced activities of daily live; CPF, composite physical function (projected ability for physical independence).

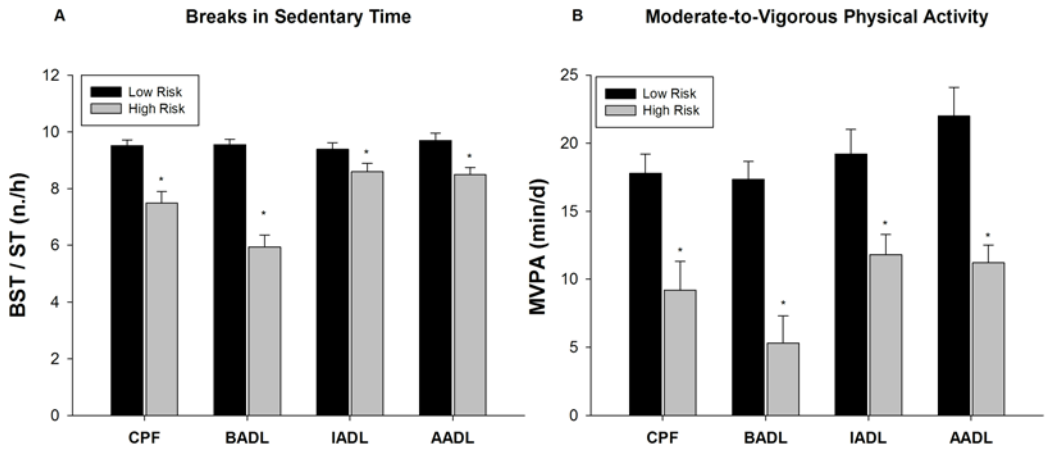

Fig. 2. Breaks in sedentary time and moderate-to-vigorous physical activity in older adults by low and high risk categories for impairment in activities of daily living

Abbreviations: MVPA, moderate-to-vigorous physical activity; BST/ST, number of breaks per hour of sedentary time; CPF, composite physical function (projected ability for physical independence); BADL, basic activities of daily living; IADL, instrumental activities of daily living; AADL, advanced activities of daily living.

*Significant differences between groups ($p < 0.05$).