Journal of Physical Activity Research, 2016, Vol. 1, No. 1, 31-35
Available online at http://pubs.sciepub.com/jpar/1/1/7

DOI:10.12691/jpar-1-1-7

Time Spent in Select Physical Activity Intensities and Sedentary time, Associations with Physical Capacity in Inactive Older Adults

Craig CM[1], Sénéchal M[1], McLellan AG[1], Slaght J[2], Bouchard DR[1,*]

[1]Faculty of Kinesiology, University of New Brunswick, Fredericton New Brunswick, Canada
[2]Faculty of Kinesiology and Recreation Management, University of Manitoba, Winnipeg Manitoba Canada
*Corresponding author: danielle.bouchard@unb.ca

Abstract The purpose of this study was to examine the relationship between physical activity (PA) intensities and physical capacity (PC) in older adults. A total of 44 people age 65 and above were recruited. PA intensities (sedentary, light, moderate and vigorous) were captured using an accelerometer. PC was measured using eight different objective tests assessing balance, endurance, strength, and flexibility. A global score for PC was calculated on eight individual capacity tests. A score of one was given for each PC test for a result reaching the average norm for their 5-year age group and sex. Time spent in moderate (r = 0.51) and vigorous (r = 0.46) intensities were associated with a greater global PC score (p<.01). Once adjusted for confounders, moderate activity was the only intensity significantly associated with the global PC score. PA at moderate and vigorous intensities, but not sedentary and light are associated with PC.

Keywords: *aging, exercise, lifestyle, sitting, functional, independence*

Cite This Article: Craig CM, Sénéchal M, McLellan AG, Slaght J, and Bouchard DR, "Time Spent in Select Physical Activity Intensities and Sedentary time, Associations with Physical Capacity in Inactive Older Adults." *Journal of Physical Activity Research*, vol. 1, no. 1 (2016): 31-35. doi: 10.12691/jpar-1-1-7.

1. Introduction

Independence in older adults is crucial to remain healthy and independent [12]. Many elements are needed to remain independent; one of them is an adequate physical capacity (PC) to perform daily tasks, which includes strength, endurance, flexibility and balance [12,22,23]. Maintaining an acceptable PC level is essential because it is associated with frequency of hospitalization, the number of days stayed at the hospital (Sari, 2010), and the age at which one will be admitted to nursing home [4,18]. Strategies have been explored to increase or maintain PC in older adults, including becoming more physically active and sitting less [11]. The newest Canadian Physical Activity Guidelines for older adults were based on maintaining and/or improving PC [20]. The guidelines call for a minimum of 150 minutes of moderate-to-vigorous aerobic exercises in 10-minute bouts, combined with two days of resistance training [25]. Only about 13% of older adults are reaching these guidelines [9]. On the other hand, the average time that Canadian adults spend in a sedentary behaviour (e.g., sitting) while awake is 9.7 hours per day and this time increases with age [11]. This result is not trivial as for each hour spent sitting, older adults increase the odds of disability by 46% [11], but it is unknown if sedentary time or light PA is associated with objective measures of PC.

Previous research regarding the association between physical activity intensities and physical capacity in older adults has not is examined in the same detail for different intensities of activities. Past findings suggest that sedentary behavior is associated with a lower PC scores in older adults [10,11,15,24]. Light activity time and its association with PC hasn't been looked at in detail, but some findings suggest that it plays a role in improving or preventing decline in the PC of older individuals [3,17]. Time spent in moderate activity has been linked to greater PC and overall health in all age groups of adults [10,15,26]. Vigorous activity time clearly predicted lower mortality rates [11], but not much is known for the association between vigorous intensity activities and PC possibly because not many older adults perform these activities [9].

The goal of this study was to evaluate the association between sedentary, light, moderate, vigorous intensity using an accelerometer, and selected objective PC tests in older adults who were considered inactive. The findings could contribute to have guidelines for time spent in sedentary time or light PA in older adults, which are considered inactive, if maintaining or improving PC is the goal.

2. Methods

2.1. Participants

Forty-four community dwellers age 65 or above were recruited for this study. The inclusion criterion for this study was to be currently inactive (< 150 minutes of moderate to vigorous PA in moderate to vigorous intensity in 10-minute bouts per week). Another inclusion criteria was be cleared to exercise based on the Physical Activity Readiness Questionnaire (PARQ+) questionnaire [7]. Exclusion criteria included having walking aid for ambulatory purpose and not be able to walk for 30 minutes for leisure. All subjects were recruited through public advertisement.

2.2. Characteristics of Sample

All participants were asked their highest level of education. The question was: "What is the highest level of education you completed?" The possible answers were elementary school, high school, college, or university. For analysis, those who did have college or university education received a value of one; others were given a score of 0. Anthropometrics measures were taken in accordance to the Canadian Society for Exercise Physiology protocol [5]. Using a stadiometer (SECA217, California, USA), participants were asked to stand up feet together, arms by their side, and look straightforward while the measurement was taken. Body weight was measured using a digital scale (OMRON HBF-5186, Illinois, USA). Participants were asked to wear light clothing with no footwear when measuring weight and height. To measure waist circumference participants were asked to remove clothing from the abdomen area, stand with feet in line with their shoulders, and place the arms across their chest. This measurement was taken twice at the superior edge of the iliac crest at the end of a normal expiration. The measure was recorded to the nearest 0.5 cm.

Cardiorespiratory Fitness level was obtained using the modified Bruce protocol [13]. The test was stopped when participants felt they could not do any more or for safety reasons. Subjects were asked to wear comfortable clothing and athletic footwear, avoid alcohol, caffeine, and food three hours before the test, and avoid strenuous activity the day of the test [1]. Once the participant was terminating the test, the highest value of oxygen (VO2peak) was recorded in ml/kg/min.

2.3. Physical Activity Level

To determine the amount of physical activity each participant was achieving during seven consecutive days, Actical accelerometers were used (Phillips – Respironics, Oregon, USA). The raw data was applied to the physical activity intensity cut-points for Actical accelerometer established by Colley et al [8]. Moderate activity was determined to be 1,535 to less than 3,962 counts. Vigorous activity was identified as 3,962 or more and light was found to be 100 to less than 1,535. Participants were asked to wear the accelerometer for seven days while the data was collected. Only participants having four or more valid days [8] were included in the study. A valid day was defined as a minimum of 10 hours of data collection and non-wear time was defined as any consecutive 60 minutes with no data [8].

2.4. Physical Capacity

As described below, eight objective tests were used to assess PC. First, the eight foot up and go test that evaluates agility and dynamic balance. Participants started seated in a chair with their feet on the ground. They were asked to push themselves out of the chair without using their hands and walk as quickly as they could around a pylon positioned eight feet away from them and then returned to a seated position [23]. Time to complete the task was recorded in seconds. The 30-second chair stand was done with the participants starting in a seated position with feet on the ground, participants were asked to stand and sit as many times as they could on a chair without arm rests in 30 seconds with their arms across their chest [23]. This test assesses lower body strength, and the number of completed repetitions was recorded. The arm curl test was done from a seated position and begins with the arm fully extended towards the ground. Participants had 30 seconds to complete as many bicep curls as they could, men used an eight-pound weight while women used a five-pound weight. This tests upper body strength, and the number of completed repetitions in 30 seconds was recorded [23]. The 6-minute walk test had participants try to cover as much distance as they could during six-minute distance trial. They walked on a 20-meter course, and at the end of six minutes they were asked to stop so that the final measurement could be taken in meters [23]. This test aims to assess aerobic endurance. The chair-sit and reach test was done sitting near the edge of a seat. Participants were asked to extend one leg and reach with both hands towards the toes, without bending their knee. The measurement was taken from the end of the fingers to the tip of the toe in centimeters. If the toes were not reached, the score was a negative value, and if the toes were passed it was a positive value [23]. This assesses lower body flexibility. The back scratch test started from a standing position, one hand reaches over the shoulder while the other reaches up the middle of the back, trying to move the middle fingers towards each other. The distance between the middle fingers was recorded as a negative value, or if there was overlap, it was a positive value [23]. This assesses upper body flexibility. The single leg balance tests with eyes open and closed were done two times each. The first two times were done with the eyes open, and the last two with the eyes closed. Participants were asked to stand on one foot with their arms across their chest and tried to hold their balance for up to 45 seconds. If the participant lost balance their time was stopped. For participants safety they were positioned close to a wall on one side, and had the back of a chair in front of them, creating the opportunity to grab something to prevent them from falling if they lost their balance [6]. This test was used to access overall balance. Scores of the eight PC tests were combined and labeled as the global PC score. For each test, each participant was given a value of one if they met the average norm for their sex and age and a score of zero if not. The average norm was obtained for their sex and their five-year age category developed by Rikli and Jones [23] for all tests, but the two balance tests where the norm was obtained from the Canadian Society of Exercise Physiology by sex for 65 years old and above [6]. As a result, the total score could range between zero and eight, and the higher the better the PC.

2.5. Statistical Analysis

Shapiro-Wilk tests were used to determine if the data was normally distributed. Pearson's or Spearman's correlations were used as appropriate between two continuous variables. Depending on the distribution or the nature of variables, men and women were compared using T-tests, Mann-Whitney tests, or Chi-square. Linear regressions were used to determine what physical activity intensities were associated with the PC global score as the dependent variable, once adjusted for variables individually associated with the global score of PC. Finally, logistic regressions were also used to identify which physical activity intensities were associated with each of the PC tests where the dependent variables were 0-1 (reaching or not the average score for sex and age 5-year age group) for each of the eight PC tests. Values are presented as mean +/- SD or median (25-75th percentile). SPSS statistics version 23 was used for data analysis.

3. Results

Table 1 shows general characteristics as a whole and stratified by sex. Seventy percent of participants were women with an average age of 69 years. The average BMI was within the overweight range for all participants. Differences were observed between men and women for height, body weight and waist circumference, with a greater value for men.

Table 1. Participants' Measurements

Characteristics/ Measurements	TOTAL (N= 44)	Men (N =13)	Women (N=31)
Age (year)	69.5 (66.0 - 73.8)	71.0 (69.0 - 76.0)	69.0 (66.0 - 73.0)
Height (m)	1.7 (1.6 - 1.7)	1.8 (1.7 - 1.8)	1.6 (1.6 -1.7)*
Weight (kg)	77.4 ± 14.0	87.1 ± 12.1	73.3 ± 12.9*
Body mass index (kg/m^2)	27.6 ± 4.1	27.9 ± 3.2	27.5 ± 4.5
Waist circumference (cm)	98.2 ± 11.1	104.7 ± 9.5	95.4 ± 10.7*
University/college degree : N (%)	25.0 (56.8)	9.0 (69.2)	16 (51.6)
		Physical capacity	
6 min walk test (m)	504.8 ± 68.8	537.3 ± 77.6	490.6 ± 60.6*
Chair Stand (reps)	11.0 (10.0 - 13.7)	11.0 (10.5 - 15.0)	11.0 (9.0 - 13.0)
Arm curl (reps)	17.2 ± 3.3	17.8 ± 3.2	17.0 ± 3.4
Back scratch (cm)	-10.3 (-17.7 - 0.50)	-13.5 (-25.5 – -7.7)	-6.0 (-16 - 2.5)*
Sit and Reach (cm)	-1.3 (-11.1 - 0.4)	-7.5 (-14.0 - 0.50)	-4.5 (-7.0 -1.0)
8 foot up and go (sec)	6.4 (5.4 - 6.9)	5.9 (5.1 - 6.8)	6.4 (5.6 - 7.1)
Single leg balance eyes open (sec)	14.3 (4.7 - 30.4)	3.7 (2.7 - 25.1)	15.6 (7.4 - 31.8)*
Single leg balance eyes closed (sec)	2.0 (1.3 - 3.1)	1.7 (1.0 - 3.1)	2.0 (1.5 - 3.3)
Global Physical Capacity Score (0-8)	3.5 ± 1.7	3.1 ± 1.8	3.7 ± 1.6
		Physical Activity and Fitness	
Sedentary time per week (min)	606.7 ± 54.1	612.4 ± 54.8	604 ± 54.5
Light PA time per week (min)	155.0 ± 59.7	145.3 ± 59.0	159 ± 60.0
Moderate PA time per week (min)	16.2 (3.00 - 27.4)	19.6 (3.5 - 25.7)	13.3 (2.6 - 28.6)
Vigorous PA time per week (min)	0.7 (0.0 - 0.7)	0.95 (0.0 - 2.1)	0.14 (0.1 - 0.7)
VO_2 peak (ml/kg/min)	25.1 ± 6.1	29.3 ± 6.8	23.2 ± 4.9*

Data presented as unadjusted mean ± SD, N (%) or Median (25-75th percentile)
* Significant difference between men and women (p<0.05).

As for cardiorespiratory fitness, participants had an average of 25.1 ± 6.1 ml/kg/min overall, with men averaging a greater value 29.3 ± 6.8, ($p < 0.01$). Of the 44 participants, 35 held a university or college degree making up 56.8 % of subjects. In terms of PC, three PC tests were significantly different between men and women; the 6 min walk test as men were able to walk further in meters, 537.3 ± 77.6 compared to 490.6 ± 60.6. The back scratch test where women performed better with an average score of 490.6 ± 60.6 cm compared to -13.5 (-25.5 – -7.7) for men. Also the single leg balance eyes open tests, where the average score for women was greater than the men, 3.7 (2.7 - 25.1) seconds compared to 15.6 (7.4 - 31.8) seconds for men. As for the global PC score was computed, men had an average of 3.1 ± 1.8 and women had an average of 3.7 ± 1.6 with no significant difference between sexes.

No significant difference was observed for any time spent at different physical activity intensities between men and women. As a whole, sedentary time and light physical activity consisted of the majority of physical activity time as only 16.17 minutes was spent in moderate intensity and not even one minute in vigorous intensity.

Table 2 presents the associations between general characteristics using continuous variables and global PC scores. Body weight (kg) was found to have a significant association with the global PC score (- 0.41, $p < 0.01$). Cardiorespiratory Fitness and BMI also were found to be associated with the global PC score, with respective values of, (0.36, $p < 0.05$) and (- 0.35 $p < 0.05$).

Table 2. Correlations Between Physical Characteristics and the Physical Capacity Global Score

Physical characteristics	Physical Capacity Global Score
Age	0.05
Body Fat mass	0.15
Fitness Level	0.35*
Body Weight	0.41**
Body mass Index	-0.35*

**. P<.01
*. P<.05.

Table 3 shows the associations between different physical activity intensities, PC tests in addition to the PC global score. Beside the single leg balance test with eyes open being associated with light physical activity intensity ($r = 0.31$; $p < 0.05$), sedentary time and physical activity time spent in light intensity were not significantly associated with any individual tests nor the global PC score. On the other hand, time spent in moderate intensity was significantly associated with four individual PC tests (i.e., 6-min walk test, chair stand, 8-foot up and go and single leg balance with eyes open) and the global PC score. Also, time spent in vigorous intensity was significantly associated with these same four PC tests as well as the global PC score.

Table 3. Correlations Physical Capacity Tests and Physical Intensities

Physical capacity tests	Light	Moderate	Vigorous	Sedentary
6 min walk test (m)	0.33	0.67**	0.45**	-0.03
Chair Stand (reps in 30 sec)	0.29	0.42**	0.35*	-0.17
Arm curl (reps in 30 sec)	0.17	0.14	0.07	-0.11
Sit and Reach (cm)	0.07	0.02	0.11	0.10
Back scratch (cm)	0.01	0.15	0.14	-0.14
8 foot up and go (sec)	-0.26	-0.47**	-0.45**	-0.02
Single leg balance eyes open (sec)	0.31*	0.40**	0.50**	-0.16
Single leg balance eyes closed (sec)	0.05	0.25	0.21	-0.11
Physical Capacity Global Score (0-8)	0.22	0.51**	0.46**	0.09

**. P<.01
*. P<.05.

Linear regressions using the global PC score and each individual score as the dependent variable were performed adjusting for sex and body mass. Moderate activity was the only physical activity intensity that remained significantly associated with the 6 min walk test (B = 2.38, P < 0.01), chair stand (B = 0.08, P= 0.02), single leg with eyes open test (B = 0.34, P = 0.02) and global capacity score (B= 0.05, P < 0.01).

Finally, logistic regressions were performed using all individual PC tests. The dependent variable was 0-1 based on participants reaching or not the average norm for age and sex. The results show that only time spent in moderate intensity was associated with reaching sex and age norms for PC tests. The 6-minute walk test and single leg balance eyes closed test were associated with time spent at moderate intensity with respective odds ratios of 0.92 (P =0.02) and 0.94, (P < 0.04).

4. Discussion

The purpose of this study was to assess the association between different physical activity intensities and PC, especially sedentary behavior and light intensity. The general finding of this study suggest that time spent in sedentary and light activities are not associated with PC in community dwellers. The findings of this study confirm past research, suggesting that moderate and vigorous activity time are associated with PC in older adults.

Contrary to our findings, some studies have observed that sedentary behavior is associated with PC [10,11,15,24]. For example, a study found that even breaking-up sedentary time was associated with better PC in older adults [24]. Another study reported that increasing sedentary time was associated with cardio-metabolic disease and all-cause mortality, independent of time spent in exercise [19]. Studies have also found that increased sedentary behavior is a risk factor for general health decline and activities of daily living disability independent of moderate to vigorous activity time [10,11,19]. Lastly, one study found that increasing sedentary time was associated with decreasing PC in older adults [10]. Results may differ from our findings because all studies mentioned above did not include the same PC measures. One used the grip strength, chair stand, balance scores, and timed up and go test scores to evaluate PC [10], but not all capacity tests were taken to obtain a total score as done in the current study. The 6-minute walk test scores were not reported in previous studies, but the 6-minute walk score is known to be a valid test in accessing PC in older adults [21]. Differences in the age of the subjects must also be noted among studies. Average ages in our study was lower than most previous studies with age reaching up to 95 years old. For example Dunlop et al., 2015reported an association between sedentary time and PC in a sample of participants which 19% were age 80 and over. It is possible that sedentary time may not be a risk factor for poor PC in younger older adults or only when activity levels and fitness decline below a certain point [26].

Many older adults are not meeting the physical activity guidelines [6,9], therefore light activity time and sedentary time is making up a major part their life. Light activity time and its association with PC haven't been looked at in detail in the past, but some findings suggest that it plays a role in improving or preventing decline in PC of older individuals [3,17]. One study found that increasing light physical activity (1.5-2.9 METs) in older adults may be a viable approach to reducing the rate of PC decline in individuals who are unable or reluctant to initiate or maintain adequate levels of moderate-intensity activities [3]. Our results may differ from past findings because of differences in baseline characteristics, older adults in past studies have lower baseline PC possibly due to age or sickness. For example, the study done by Lee et al., 2001 studied women who were already at high risk for cardiovascular diseases (CVD), or had already suffered a cardiac event. Most of these women would have a much lower PC. No data was obtained in our study regarding CVD risk factors, although with an average cardiorespiratory fitness level of 25.1 ± 6.1 ml/kg/min, which is considered average for men and women of that age [14], we can assume our sample was at a low risk compared Lee et al. 2001. Similarly, the study done by Bann et al., 2015 participants aged 70–89 years were only eligible if they were at high risk of mobility issues and they reported that time spent at light intensity was associated with PC.

Time spent in moderate activity has been linked to increase PC and overall health in all age groups of adults [10,16,26]. The result of our study confirms that moderate activity time is associated with PC. Based on our logistic regression model, for each increase of one minute spent in moderate intensity, the global PC score would increase by 0.05 point. This means that doing as little as 60 minutes of moderate activity a week could increase an older adults capacity score by three points out of eight. Time spent at vigorous activity like moderate activity was associated with four individual PC tests and the PC global score; although, the participants in this study spent less than one minute, on average, in vigorous intensity it still had an influence on PC score, this change would be expected to be greater if the time spent at this intensity was done in longer periods. A study found that increased vigorous activity time clearly predicted lower mortality rates [11], but not much is known for the association between vigorous intensity activities and PC simply because not many older adults perform these activities [9]. Past findings are lacking on vigorous intensity activity effects on PC because moderate to vigorous activity are usually examined together.

On a clinical point of view this study has the potential to impact a large number of older adults who are currently not achieving the recommended physical activity amount to optimize functional benefits. The findings suggest that sedentary time and light physical activity are not generally associated with physical capacities in older adults. As previously reported in the literature, moderate and vigorous intensity physical activities are associated with PC and should remain the main focus to optimize PC.

Limitations in this study include the small sample size, and the lack of specific cut-off for accelerometer for older adults to interpret counts per minute. The sample was predominantly women and included only community dwellers. Another limitation of our findings is information about participant's health/disease was not collected.

In conclusion, compared to moderate and vigorous time, sedentary time and light intensity are not associated with PC tests in older adults. The public message needs to stress the importance of moderate and vigorous intensities when exercising if PC is the goal in community dwellers.

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