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Sedentary behavior and physical activity in cardiac rehabilitation participants

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ABSTRACT

Background: There is a deleterious association between sedentary behavior and mortality risk factors. Elevated sedentary time has been reported in several studies that involved cardiac rehabilitation (CR) participants.
Objectives: To examine the changes in sedentary behavior, breaks in sedentary time, and physical activity (PA) in CR participants.
Methods: This was a prospective repeated measures study. Sedentary behavior and PA were assessed using accelerometer at baseline, 12 weeks, and 6 months after CR entry.
Results: At 12 weeks, participants ($n = 58$) spent more time in moderate-vigorous PA (MVPA) and tended to be less sedentary. However, the changes were lost by 6 month follow-up. Although the majority of participants met the recommended MVPA, our participants demonstrated elevated sedentary time. We found a strong positive correlation between time in light PA and number of breaks in sedentary time; neither of which showed any changes over time.
Conclusions: By promoting MVPA as their main target, current CR programs may have little impact on changing the elevated sedentary behavior of their participants. Further, interrupting sedentary time with light PA could be an achievable strategy to reduce sedentary behavior in CR participants.

Introduction

It is well known that there is a deleterious association between sedentary behavior and mortality risk factors independent of moderate-vigorous physical activity (MVPA).[1,2] With every hour increase in sedentary time beyond 7 h/day, there is a 5% increase in mortality.[3] With current cardiac rehabilitation (CR) programs being focused mainly on MVPA, sedentary behavior has often been overlooked in CR participants.[4] By increasing exercise (i.e., regimented MVPA) during CR, these programs successfully improve exercise capacity in CR participants. However, they might not be as successful in reducing overall sedentary behavior.[5,6] Elevated sedentary time has been reported in several studies that involved CR participants.[4,7–11]

There is evidence suggesting a deleterious association between prolonged uninterrupted sedentary time and cardio-metabolic markers; whereas interrupting sedentary time with activity breaks has been shown to be beneficial in improving these markers.[12–14] In fact, there is a significant correlation between the number of breaks in sedentary time and lower levels of cardio-metabolic risk factors.[12] This highlights the importance of breaks in sedentary behavior throughout the day, independent of the total time spent sedentary. Healy et al.[12] suggested that the beneficial effects of breaks in sedentary time may be attributed to increase in total energy expenditure. Furthermore, it has been reported that in older adults, increasing the number of breaks in sedentary time is associated with enhanced ability to manage activities of daily living (ADL).[15]

Evaluation of the sedentary behavior in CR participants may provide insight into efficacy of CR programs on overall daily activity. Therefore the purpose of this study is to examine the changes in sedentary behavior, breaks in sedentary time, and physical activity (PA) in CR participants from commencing CR to 6 months after CR entry. In addition we examined the relationships between the number of breaks in sedentary time, and time spent in light and MVPA.

Methods

Study design and participants

This was a prospective repeated measures study examining sedentary behavior and PA in CR participants as they progressed through

Abbreviations: ADL, activities of daily living; CR, cardiac rehabilitation; EE, energy expenditure; METs, metabolic equivalents; MVPA, moderate-vigorous physical activity; PA, physical activity; SWA, SenseWear Mini Armband

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the program from CR entry to 12 weeks to 6 months after CR entry. Patients who were referred to CR were recruited. Patients were excluded if they had: 1) severe heart failure (New York Heart Association class III or IV); 2) severe cognitive impairment; or 3) any condition which might preclude the patient's ability to perform moderate intensity exercise. Upon obtaining written informed consent, demographic information was documented followed by baseline assessments. Participants were assessed again at 12 weeks and 6 months after CR entry. This study was approved by the university health research ethics review board.

Exercise program

We recruited patients from two centers that offered supervised CR program. A description of the two programs has been published previously.[16] Participants attended 8–12 weeks of CR program. The program involved 1–2 sessions /week of supervised exercise. Participants were given activity logs and were encouraged to supplement their exercise program with 1–4 additional sessions/week independently. Exercise training regimen included aerobic training (e.g., treadmill, cycle ergometer, or elliptical trainer) which incorporated a warm-up (5 min), steady-state exercise (20–60 min), and a cool-down (5 min). During steady-state exercise, participants exercised at a perceived exertion level of 12–14 (on the Borg 6–20 scale). During the program, participants had access to variety of education classes including a session on exercise and leading an active lifestyle.

Outcome measures

Physical activity and sedentary behavior. Daily PA and sedentary behavior were assessed objectively using the SenseWear Mini Armband (SWA; BodyMedia, Pittsburgh, PA). The SWA uses multiple sensors (3-axis accelerometer, heat flux, galvanic skin response, and skin temperature) to estimate energy expenditure (EE). The SWA has been shown to be valid and reliable and has been used in several studies.[9,17–20] Participants were instructed to wear the SWA continuously for 5 days except during bathing or swimming. Only days where the SWA was worn for ≥10 waking hours/day were included for analysis.[6] The SWA also provides estimates of sleep time.[21] For the purpose of this study, sleep data were excluded.

We used minute by minute EE data to obtain information on sedentary time and the time spent in different PA intensities. Sedentary behavior includes activities that increase EE slightly above the resting level; and was defined as waking time with an EE ≤ 1.5 metabolic equivalents (METs).[22,23] Any interruption in sedentary time that lasted for ≥1 consecutive minutes was considered a break (EE > 1.5 METs). Data were inspected to determine the number of breaks as well as the mean length of the breaks (min) in sedentary time. Light PA was defined as activities which required an EE of 1.6–2.9 METs (e.g., ADL).[22] MVPA included activities with an EE ≥ 3.0 METs.[24]

Statistical analysis

Baseline characteristics data are presented as mean ± standard deviation or absolute number (percentage) (Table 1). Normality of the data was analyzed using the Kolmogorov–Smirnov test. Repeated measures analysis of variance was used to analyze the changes in variables with normal distribution. Changes in variables with violated normality assumption were analyzed using Friedman's analysis of variance. Bonferroni for pairwise comparisons and Wilcoxon Signed Ranks tests with Bonferroni corrections were used for post-hoc analyses. Further, the relationships between the number of breaks in sedentary time, and time spent in light and MVPA were analyzed using Pearson correlations. All statistical tests with a $p < 0.05$ were considered significant. All analyses were conducted using SPSS (version 24).

Table 1
Clinical and demographic characteristics of the sample ($n = 58$)

Age (years)	61 ± 9
Male	46 (79.3)
BMI (kg/m^2)	29.0 ± 5.0
Caucasian	51 (87.9)
Married	50 (86.2)
Living alone	7 (12.1)
Post-secondary education (≥Bachelor's degree)	21 (36.2)
Current smoker	9 (15.5)
Previous smoker	35 (60.3)
Obesity	23 (39.7)
Primary diagnosis ($n = 57$)	
Angina	18 (31.6)
MI	39 (68.4)
Treatment strategy ($n = 58$)	
PCI	36 (62.1)
CABG	9 (15.5)
Medical	13 (22.4)
DM ($n = 45$)	9 (20.0)
HTN ($n = 45$)	34 (75.6)
Dyslipidemia ($n = 45$)	37 (82.2)

Data are presented as mean ± standard deviation or as the absolute number (percentage).
BMI, body mass index; CABG, coronary artery bypass graft; DM, diabetes mellitus; HTN, hypertension; MI, myocardial infarction; PCI, percutaneous coronary intervention.

Results

A total of 83 patients were recruited. Data from 25 participants who refused follow-up assessments ($n = 15$) or their CR program was terminated due to medical issues ($n = 10$), were excluded. Fifty-eight participants who attended in all the 3 assessment points were included in the analysis (Figure 1). Attendance was calculated as a percentage of the supervised exercise sessions which were offered at each center. Participants attended in average of 75 ± 29% of the supervised sessions offered at the centers. Baseline characteristics are presented in Table 1. Participants wore the SWA for 5.3 ± 0.7 days (21.9 ± 1.0 h/day) at baseline, 5.0 ± 0.8 days (22.3 ± 1.0 h/day) at 12 weeks, and 5.0 ± 0.9 days (22.2 ± 1.1 h/day) at 6 months after CR entry.

Sedentary time was calculated as percentage of waking time spent in sedentary behavior. There was a significant change in sedentary time over the course of the study ($p < 0.05$). From baseline to 12 weeks, there was a trend towards a reduction in sedentary time. However, when a Bonferroni correction was applied to the pairwise comparison, the change in sedentary time (from baseline to 12 weeks) was not statistically significant ($p = 0.106$). From 12 weeks to 6 months, sedentary time increased significantly; and at the 6 month assessment point, sedentary time was comparable to that observed at the baseline (12 weeks vs. 6 months, $p < 0.05$; baseline vs. 6 months, $p = 1.000$) (Table 2).

Breaks in sedentary time. There was no significant change in number of breaks in sedentary time over the course of the study ($p = 0.799$) (Table 2). The mean length of the breaks changed significantly from baseline to 12 weeks to 6 month follow-up ($p < 0.05$). From baseline to 12 weeks, mean break length increased by 15.4% ($p < 0.05$). However, it returned to the baseline level at 6 month follow-up (12 weeks vs. 6 months, $p < 0.05$; baseline vs. 6 months, $p = 1.000$) (Table 2).

Time in different physical activity intensities. There was no significant change in percentage of waking time spent in light PA over the course of the study ($p = 0.280$) (Table 2). The percentage of waking time spent in MVPA changed significantly from baseline to 12 weeks to 6 month follow-up ($p < 0.05$). From baseline to 12 weeks, MVPA time increased significantly (baseline: 6.9 ± 5.4% vs. 12 weeks:

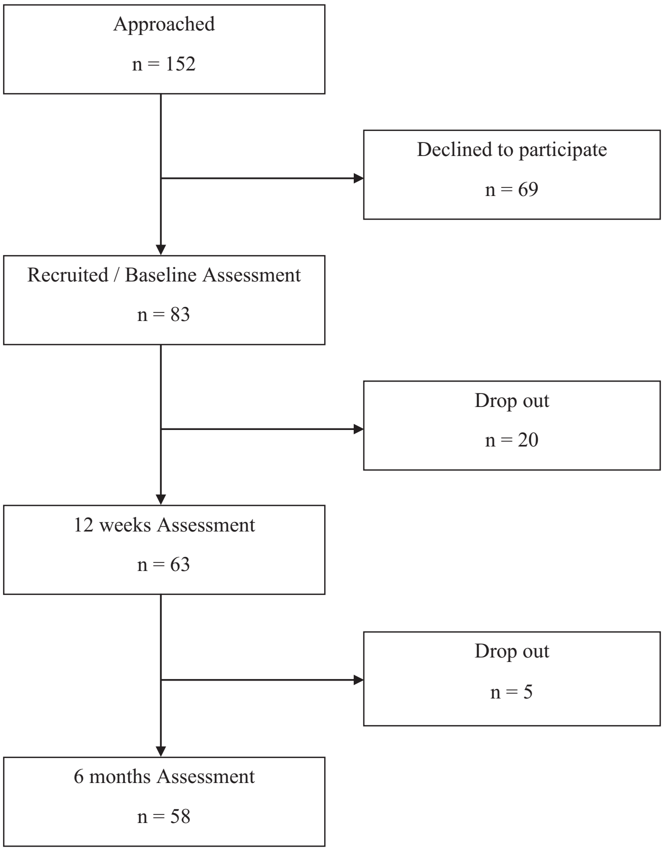

Fig. 1. Flow diagram of participants.

9.1 ± 6.8%, $p < 0.05$). However, it returned to the baseline level at the 6 month follow-up (12 weeks vs. 6 months: 7.1 ± 5.8%, $p < 0.05$; baseline vs. 6 months, $p = 0.813$) (Table 2).

Relationship between the number of breaks, and light and MVPA. There were strong positive correlations between the number of breaks in sedentary time and time spent in light PA at all 3 assessment points (baseline: $r = 0.75$, $p < 0.05$; 12 weeks: $r = 0.70$, $p < 0.05$; 6 months: $r = 0.73$, $p < 0.05$). Correlation between the number of breaks in sedentary time and time spent in MVPA was weak at the baseline and was not statistically significant at the follow-up assessments (baseline: $r = 0.28$, $p < 0.05$; 12 weeks: $r = 0.21$, $p = 0.106$; 6 months: $r = 0.05$, $p = 0.698$).

Discussion

The purpose of this study was to examine the changes in sedentary behavior and PA from commencing CR to 6 months after CR entry. In addition we examined the relationships between the number of breaks in sedentary time, and time spent in light and MVPA. Findings indicate that at 12 weeks, our participants spent more time in MVPA and tended to be less sedentary. However, the changes were lost by 6 month follow-up. Although the majority of participants met the recommended MVPA, our participants demonstrated elevated sedentary time over the course of the study. Further, we found a strong positive correlation between time in light PA and number of breaks in sedentary time; neither of which showed any changes over time.

In the present study, the significant increase in MVPA time with CR is consistent with findings from previous studies.[4,6,25] However, in contrast with the study by ter Hoeve et al.,[4] our participants did not retain the increase in MVPA time at the 6 month follow-up. This observation may be attributed to the fact that ~70% of our participants met the recommended level of MVPA (i.e., 30 min/day)[26] at all 3 assessment points (baseline: 75.9%, 12 weeks: 75.9%, 6 months: 67.2%). Indeed, more than 50% of our participants accumulated the recommended level of MVPA through continuous bouts of ≥10 min (baseline: 53.4%, 12 weeks: 65.5%, 6 months: 51.7%) versus what was reported in ter Hoeve et al.[4] study (i.e., 17.8%, 13.5%, and 13.2%). Moreover, our participants achieved a greater improvement in MVPA time (2.2% of waking hours = 20.9 min) than the small change that was observed in ter Hoeve et al.[4] study (0.65% of waking hours = 5.7 min). Thus, it appears that our participants were simply unable to sustain, on an ongoing basis, the 1.44 h/day (~86 min/day) of MVPA that was achieved at 12 weeks. However, the comparison between the studies is limited due to differences in the measurement methods.

The changes in MVPA are in line with the trend of changes observed in sedentary time that tended to decline at 12 weeks and returned to baseline at the follow-up. However, despite the improvement in MVPA during the initial 12 weeks and the fact that the majority of participants met the recommended level of MVPA, our participants demonstrated elevated sedentary time over the course of the study. Upon commencing CR, our participants spent ~72% of their waking time sedentary. At its lowest level, at 12 weeks after CR entry, sedentary time was still high (68% of waking hours). This is consistent with findings from other studies involving CR participants.[4,7–9] These findings suggest that the current CR programs may have little impact on changing the elevated sedentary behavior of

Table 2
Changes in sedentary behavior and physical activity from baseline to 12 weeks to 6 months after cardiac rehabilitation entry ($n = 58$)

	Baseline	12 weeks	6 months	p
SWA on-body time (waking hours/day)	15.76 ± 1.32	15.94 ± 1.06	15.84 ± 1.13	0.501
Sedentary time (% of waking hours)	71.6 ± 12.1 (11.30 ± 2.23 h/day)	68.0 ± 13.8 (10.81 ± 2.14 h/day)	71.4 ± 11.8† (11.29 ± 2.13 h/day)	0.030
Breaks (number/day)	31.6 ± 10.7	32.5 ± 10.8	31.8 ± 9.3	0.799
Mean break length (min)	8.6 ± 2.8	10.0 ± 4.0*	8.8 ± 3.5†	0.010
Light PA (% of waking hours)	21.5 ± 8.6 (3.38 ± 1.42 h/day)	22.9 ± 9.4 (3.69 ± 1.60 h/day)	21.6 ± 8.9 (3.43 ± 1.49 h/day)	0.280
MVPA (% of waking hours)	6.9 ± 5.4 (1.08 ± 0.86 h/day)	9.1 ± 6.8* (1.44 ± 1.10 h/day)	7.1 ± 5.8† (1.12 ± 0.91 h/day)	0.015

Data are presented as mean ± standard deviation.
Break, any interruption in sedentary time for ≥ 1 consecutive minutes (>1.5 METs); Light, 1.6–2.9 METs; MVPA, moderate-vigorous (≥3 METs) physical activity; PA, physical activity; Sedentary, waking time ≤ 1.5 METs; SWA, SenseWear Mini Armband.
* Significant change from baseline to 12 weeks.
† Significant change from 12 weeks to 6 months.No significant change from baseline to 6 months.$p < 0.05$ is considered significant.

their participants. This confirmed the findings from a study by Biswas et al.[6] Those authors examined sedentary behavior and PA during CR program and reported no changes in sedentary time despite a significant improvement in time spent in MVPA as well as the higher percentage of participants meeting the recommended MVPA. They concluded that programs that focus on exercise might not be successful in reducing sedentary behavior.[6]

Replacing sedentary time with spontaneous PA (i.e., light PA) can not only reduce sedentary behavior, but also independently lead to substantial metabolic, cardiovascular, and mortality benefits.[1,6,27–29] Previous studies reported strong correlation between changes in sedentary behavior and changes in light PA; and suggested that replacing sedentary behavior with light PA, being easy to implement, can be a feasible strategy to decrease ongoing sedentary behavior.[1,27,29–31] In the present study, we did not find any significant change in time spent in light PA over the course of the study; whereas ter Hoeve et al.[4] demonstrated significant increase in light PA that was maintained at follow-up. Those authors also examined the distribution of the sedentary behavior and reported more fragmented sedentary time with increased number of breaks. However, we did not find any change in the number of breaks in the present study. Interestingly when we examined the association between the number of breaks in sedentary time and time spent in Light and MVPA, we found that the number of breaks in sedentary time was strongly correlated with light PA at all the assessment points. These findings strengthen the hypothesis that frequent breaks of light intensity may be an important factor in sedentary behavior change in long-term. In fact, it has been suggested that interrupting sedentary time with light PA breaks, being feasible to apply to variety of settings (e.g., workplace, etc.), may be easier to achieve and maintain compared to increasing MVPA which is hard to sustain in long-term.[12,32,33] Findings from the study by ter Hoeve et al.,[4] reaffirms this by demonstrating increase in light PA and number of breaks in sedentary time, and decrease in sedentary behavior that was maintained at 1 year follow-up.[4]

A recent study on CR programs reported that both CR participants and staff tend to focus more on increasing exercise time (i.e., regimented MVPA) compared to reducing sedentary behavior.[5] Therefore, habitual PA has often been overlooked in CR participants. Our present findings support the argument put forth by other studies when they suggested that exercise and sedentary behavior are two distinct aspects which need to be targeted separately.[3,34] Biswas et al.[5] recommended a revised approach in CR programs with using strategies for sedentary behavior change in addition to promoting exercise (i.e., regimented MVPA). They suggested that CR programs should consider enhancing participants' awareness on the health benefits of taking frequent breaks in sedentary time in addition to exercise. Further, using an approach in which CR participants and staff agree on an easily achievable and sustainable goal has been recommended as an effective strategy to change the sedentary behavior in this population.[5]

Study limitations

Present findings should be interpreted with caution. With $\alpha = 0.05$ and sample size of $n = 58$, this study had the power of 0.64 to detect the change in sedentary time with the effect size of Partial Eta Squared = 0.063. Thus, a larger sample could give us the advantage of higher power to detect the changes in the variables. Moreover, we could investigate the larger sample more deeply by stratifying it into groups with different characteristics (e.g., gender, comorbidities, etc.). Moreover, this study was an observational study with no control group. However, as exercise is considered a core component of CR program, including a non-exercise control group was not possible.

Further, only participants who attended in all the 3 assessment points were included in the analysis. Therefore, the pattern of changes in PA could have been different in the participants who did not attend the follow-up assessments. However, when we compared the baseline clinical and demographic characteristics and PA markers of the drop outs ($n = 25$) with the participants who attended in all the 3 assessment points ($n = 58$), there was no significant difference between the two groups. Lastly, although participants were instructed to record the number of independent exercise sessions in the activity logs, we did not obtain sufficient data because of the low response rate. This may be avoided by using reminders in future studies.

Conclusions

Findings indicate that despite optimal level of MVPA, CR participants demonstrated elevated sedentary time from commencing CR to 6 month follow-up. This supports the notion that by promoting MVPA as their main target, current CR programs may have little impact on changing the elevated sedentary behavior of their participants. Further, a strong association between light PA and number of breaks in sedentary time suggested that interrupting sedentary time with light PA could be one of the strategies to reduce sedentary behavior in CR participants. Considering that lower intensity PA is easier to achieve and maintain in inactive individuals, this might result in more sustainable change in sedentary behavior in CR participants.

Declarations of interest

None.

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