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Impact of supervised exercise rehabilitation on daily physical activity of cardiopulmonary patients

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ABSTRACT

Objectives: The purpose of this study was to assess the impact of exercise rehabilitation (ER) on the daily physical activity (PA) of cardiopulmonary patients.
Background: The impact of ER programs on the objectively measured quantity and quality of daily PA in cardiopulmonary patients is not completely understood.
Methods: Participants' exercise capacity and PA were measured at baseline and at the end of the ER program ($n = 37$).
Results: Exercise capacity was higher at the end of the ER. Participants' sedentary time decreased while time spent in light PA increased; however, time spent in moderate-vigorous PA (MVPA) did not change. There was an increase in steps/day $_{(>1.5\ METs)}$ and PA energy expenditure (PAEE) $_{(>1.5\ METs)}$; whereas steps/day $_{(\geq 3METs)}$ and PAEE $_{(\geq 3\ METs)}$ remained unchanged.
Conclusions: Findings imply that changes in daily PA in patients participating in ER occur in activities where the EE is in light intensity rather than in MVPA.

Introduction

It is well known that there is an inverse linear relationship between amount of aerobic physical activity (PA) and mortality in patients with cardiopulmonary disorders. In fact, regular aerobic PA of moderate to vigorous intensity has been associated with a lower risk of all-cause mortality, respiratory-related hospitalizations and mortality, as well as the incidence of and mortality from cardiovascular disease.[1–5] Consequently, aerobic PA is considered a core component of cardiopulmonary rehabilitation programs.[6,7] While an improved exercise capacity is considered one of the benchmark outcomes associated with completion of an exercise rehabilitation (ER) program,[8,9] research suggests that this increased exercise capacity may not be indicative of a more active lifestyle following completion of the ER program.[10] Indeed the impact of ER programs on the objectively measured quantity and quality of daily PA in cardiopulmonary patients is not completely understood.

Earlier studies which have attempted to objectively measure daily PA of ER participants have reported mixed findings, which may be attributed to the types of devices used to assess PA.[10–18] PA outcomes reported in these studies have been obtained using devices such as simple accelerometers which provide only a general view of PA status (e.g., vector magnitude, signal counts, mean activity score, etc.). By integrating accelerometer data with data from multiple physiological sensors a more accurate measure of the entire spectrum of PA from low-intensity PA, which is often underestimated by simple accelerometers, to vigorous PA may be obtained.[19] Therefore the purpose of this study was to use a multi-sensor device to objectively assess the impact of a supervised ER program on the quantity and quality of daily PA of patients with cardiopulmonary disorders.

Abbreviations: PA, physical activity; ER, exercise rehabilitation; CABG, coronary artery bypass graft; NYHA, New York Heart Association; 6 MWT, 6 min walk test; SWA, SenseWear Pro™ Armband; EE, energy expenditure; METs, metabolic equivalents; ADL, activities of daily living; MVPA, moderate-vigorous physical activity; $MVPA_{10+}$, moderate-vigorous physical activity in bouts ≥10 min; PAEE, physical activity energy expenditure; $PAEE_{10+}$, physical activity energy expenditure in bouts ≥10 min; BMI, body mass index; MI, myocardial infarction; NSTEMI, non ST segment elevation myocardial infarction; STEMI, ST segment elevation myocardial infarction; COPD, chronic obstructive pulmonary disease.

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Methods

Study design and participants

This was a prospective one group pretest-posttest study. Participants were cardiac or pulmonary patients who participated in supervised ER programs. Both males and females ≥60 years of age were included. All participants were medically stable (i.e., no changes in medication during the study), receiving optimal medical therapy and were able to participate in exercise. Patients were excluded if they had 1) exercise-limiting non-cardiopulmonary comorbidity (i.e., orthopedic, neuromuscular, etc.); 2) uncontrolled hypertension (resting, seated blood pressure ≥ 160 systolic or ≥ 90 diastolic); 3) unstable cardiac disease or previous coronary artery bypass graft (CABG) surgery, or New York Heart Association (NYHA) functional classification class III or IV; 4) recent respiratory exacerbation; 5) required supplemental oxygen; 6) cognitive dysfunction; or 7) there was a profound language barrier. This study was approved by the university's health research ethics board and written informed consent was obtained from each participant prior to their entry into the study.

Patients referred for ER who met the inclusion criteria were approached by an ER staff member and informed about the ongoing study. Those who expressed an interest in participating were contacted by one of the investigators and the study was explained in detail. Upon obtaining written informed consent, demographic information was documented followed by baseline assessments. Participants completed a twice weekly ER program (i.e., 8–10 weeks, 16–20 sessions in total) in either a cardiac or pulmonary ER facility. Exercise sessions consisted of stretching, aerobic, and strengthening exercises. Aerobic training was performed on a treadmill or cycle ergometer for 40 min at the intensity based on patients' exercise tolerance. All participants were encouraged to supplement their ER program with unsupervised PA on non-training days. Moreover, topics such as staying active were discussed in education classes. At the end of the ER program all assessments were repeated.

Outcome measures

Exercise capacity

To assess exercise capacity, a 6 min walk test (6 MWT) was completed following the American Thoracic Society guidelines.[20] During the test participants were allowed to stop and rest whenever they wanted. The test was stopped if participants experienced chest pain, intolerable dyspnea, leg cramps, staggering, diaphoresis, or became pale or ashen in appearance.

Physical activity (PA)

Daily PA was assessed objectively using the SenseWear Pro™ Armband (SWA; BodyMedia, Pittsburgh, PA). The SWA is a dual axis accelerometer that uses multiple additional sensors (i.e., heat flux, galvanic skin response, near body temperature, and skin temperature) to estimate energy expenditure (EE). It also provides information about step counts (steps/day) and time spent in different intensities of PA (i.e., sedentary, light, moderate or vigorous). The SWA has been validated against the doubly labeled water technique and has shown strong correlation with it when estimating daily EE ($r = 0.89$).[19] The SWA has been shown to be a valid device to assess PA in many populations (e.g., both cardiac and pulmonary patients).[21,22] It should be noted that this device does not provide information on the type of PA; however our focus was on the intensity and duration of PA.

Participants were instructed to wear the SWA on the back of the upper right arm for at least 3 full days. They wore the device throughout the day and removed it when bathing or showering. To ensure an accurate representation of their daily PA, the average of three days was used. Using the SWA data, steps/day was calculated by averaging the total number of steps taken each minute for all three days. As it has been recommended that a minimum of 5500 steps/day is associated with optimal health benefits in sedentary older adults and/or individuals with disability and chronic conditions, we also recorded the number of participants meeting this target at each assessment point.[23]

Using EE data we obtained information on the time spent in different PA intensities. Participants were considered sedentary whenever energy expenditure was ≤1.5 metabolic equivalents (METs).[24] Sedentary waking time was also calculated after excluding the sleep data from overall sedentary time. Light PA was defined as activities which required an energy expenditure of 1.6–2.9 METs [e.g., activities of daily living (ADL)].[24] Moderate to vigorous PA (MVPA) included activities with an energy expenditure of ≥3.0 METs.[25]

For time spent in MVPA guidelines recommend accumulating bouts of at least 10 min.[5,26] Therefore we inspected the data to determine both the total minutes of MVPA and continuous MVPA occurring in ≥10 min bouts (i.e., $MVPA_{10+}$). To count as an $MVPA_{10+}$ the bout had to exceed the moderate intensity cut-point of 3 METs for a minimum of 10 consecutive minutes with allowance for a maximum of two observations falling below the cut point during the period (i.e. 8 out of 10 min).[27] For both total MVPA and $MVPA_{10+}$ we also recorded PA energy expenditure (PAEE) (i.e., $PAEE_{(\geq 3\ METs)}$ and $PAEE_{10+\ (\geq 3\ METs)}$). The $PAEE_{(\geq 3\ METs)}$ is often used as the threshold intensity required for the health benefits.[5,26] In this study of older adults with cardiopulmonary disorders, we also used the second marker which was defined as PA requiring an energy expenditure >1.5 METs (i.e., $PAEE_{(>1.5\ METs)}$); and is an appropriate measure of the sedentary/activity threshold for older adults.[28]

Statistical analysis

Normality of the data was analyzed using the Kolmogorov–Smirnov test. Changes in variables with normal distribution were analyzed using paired *t*-tests. Wilcoxon Signed Ranks tests were used to analyze the changes in variables with violated normality assumption. Further, some secondary analyses were undertaken to address the concern that the dependent variables might have been influenced by the patient group (i.e., cardiac vs. pulmonary). Participants' demographics at baseline were compared between the two patient groups using un-paired *t*-test (normally distributed variable), Mann–Whitney *U* test (non-normal variable) or chi-squared statistics (categorical variable). Mixed Between-Within Subjects Analysis of Variances were used to determine if the patterns of changes in variables over time were parallel across the two patient groups.

The McNemar test was used to analyze the change in proportion of participants who met the minimum recommended daily steps criteria from baseline to end of ER. The relationships between change in 6 MWT distance and changes in measures of PA were also analyzed using Pearson correlations. All tests with a $p < 0.05$ were considered significant. All analyses were conducted using SPSS version 21.

Results

A total of 37 patients (16 cardiac: 21 pulmonary) with the mean age of 75 years participated in this study. Baseline demographics and clinical data are presented in Table 1. Participants wore the SWA for 21 ± 3 h/day at baseline and 20 ± 3 h/day at the end of ER ($p = 0.149$). All but one participant completed the 6 MWT.