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The impact of moderate intensity physical activity on cardiac structure and performance in older sedentary adults ☆

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ABSTRACT

Background: Sedentary aging leads to adverse changes in vascular function and cardiac performance. We published improvements in vascular function with moderate intensity physical activity (PA) in continuous bouts. Whether moderate intensity PA also impacts cardiac structure and cardiovascular performance of the aging left ventricle (LV) is unknown.
Methods: We recruited and analyzed results from 102 sedentary older adults ages ≥50 from a randomized controlled trial with 3 study groups: control (group 1), a pedometer-only intervention (group 2), or a pedometer with an interactive website employing strategies to increase habitual physical activity (PA, group 3) for 12 weeks. Transthoracic echocardiograms were performed prior to and following the 12 week intervention period to assess cardiac morphology, left ventricular (LV) systolic performance, LV diastolic function, and arterial and LV ventricular elastance. Step count and PA intensity/distribution were measured by a pedometer and an accelerometer.
Results: We found no significant changes in cardiac morphology. Further, we found no improvement in the aforementioned cardiac functional parameters. Comparing those who achieved the following benchmarks to those who did not showed no significant changes in cardiac structure or performance: 1) 10,000 steps/day, 2) ≥30 min/day of moderate intensity physical activity, or 3) moderate intensity PA in bouts ≥10 min for ≥20 min/day
Conclusions: In sedentary older adults, increasing moderate intensity PA to currently recommended levels does not result in favorable changes in LV morphology or performance over 12 weeks. More prolonged exposure, higher PA intensity, or earlier initiation of PA may be necessary to see benefits.

1. Introduction

Sedentary aging leads to adverse structural adaptations of the heart and circulatory system. These changes include increased arterial elastance, impaired left ventricular diastolic relaxation and compliance, and increased left ventricular systolic elastance [1]. While the coupling relationship of ventricular and arterial compliance is closely maintained with matching increases in both physiological attributes, the changes leave sedentary older adults at greater risk for cardiac ischemia and heart failure [2,3].

Interestingly, life-long endurance physical activity is associated with significant mitigation of age-associated declines in left ventricular performance and arterial compliance [4]. However, whether increasing moderate intensity PA (3–6 metabolic equivalents, METs) to currently promulgated goal levels in older adults can reverse this adverse ventricular and arterial remodeling is unclear. In the context of a 12 week randomized control trial targeting an activity goal of 10,000 steps/day, we recently showed that increasing moderate intensity PA can reverse age-related vascular endothelial dysfunction in previously sedentary older adults [2]. In the context of this study, we evaluated the effects of increasing moderate intensity PA on cardiovascular performance profile in older sedentary adults.

☆ Clinical Trials Registration: Clinicaltrials.gov NCT0121297.

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2. Methods

2.1. Subjects

114 sedentary older adults (ages ≥50 and ≤80 years of age) were recruited for this study based at the Medical College of Wisconsin (Milwaukee, WI) between 2010 and 2012. The methods and design of the randomized clinical trial have been previously described in detail [2]. Briefly, screened participants aged ≥50 years old who averaged ≤8000 steps/day (measured by an Omron HJ-720ITC pedometer (Omron, Lake Forest, IL)) over 1 week and met all other previously reported inclusion criteria were randomized. We excluded individuals with uncontrolled hypertension (≥160/100), recent myocardial infarction (within 1 month of enrollment), angina, clinical evidence of heart failure or documented left ventricular ejection fraction of ≤45%, renal insufficiency, liver dysfunction, active malignancy, or cognitive impairment. Only 4 participants reported a prior history of coronary artery disease, and all had normal ejection fractions without wall motion abnormalities. The study protocol was approved by the Medical College of Wisconsin's Institutional Research Board, and all participants provided written informed consent. Subjects were randomized into 1 of 3 intervention groups: 1) control, 2) pedometer only with verbal instructions to reach 10,000 steps by increasing step count by 10%/week and 3) a pedometer with access to an interactive website designed to teach ways of integrating moderate intensity physical activity into daily life with the same step count goal as group 2 as previously described [2].

2.2. Study visit procedures (prior to and following the 12 week intervention period)

2.2.1. General procedures

All subjects fasted overnight prior to their study visit. Height and weight were measured in metric units. Waist circumference was measured at the level of the umbilicus while standing. Heart rate and blood pressure (BP) were measured in triplicate and averaged.

2.2.2. Physical activity procedures

PA was measured and intensity was categorized as previously described [2]. Briefly, step count and accelerometry data were collected using Omron HJ-720ITC and ActiGraph GT3X (ActiGraph GTX3, ActiGraph, Pensacola, FL), for 1 week at the time of enrollment and during the final week of the 12 week intervention period.

For the accelerometer data, time blocks of ≥60 min of continuous activity count of zero was removed from analysis. This was considered time when the monitor was not worn. To be considered valid for a given day, we required the accelerometer to be worn for a minimum of 600 min/day. Participants with ≥4 days of valid accelerometer data were included in the analysis. For each minute, the accelerometer data was coded as sedentary activity (0–100 counts, <1.5 MET intensity), light activity (101–1951 counts, 1.5–3 METs), moderate intensity activity (1952–5924 counts, 3–6 METs), or vigorous activity (>5925 counts, >6 METs) [5]. Further, a continuous bout of moderate or vigorous intensity PA was defined as ≥10 consecutive minutes at the aforementioned PA intensity.

2.3. Transthoracic echocardiogram

Complete resting transthoracic echocardiograms were performed following an overnight fast and in resting state by a registered cardiac sonographer at baseline and 12 weeks. All images were obtained using a Vivid 7 (General Electric, Milwaukee, WI), with an M3S sector transducer (1.5–4.6 MHz) and obtained by a registered cardiac sonographer experienced in echocardiographic imaging. All image analyses were performed off line using standard GE software (EchoPAC). All quantitative measurements were made in triplicate and averaged for the final reported value. The images were obtained from the parasternal, apical, and subcostal windows by an established protocol. The parasternal view provided a full standard view, depth reduced view to evaluate the left ventricular (LV) size and wall thickness, and the zoom in view to evaluate the left ventricular outflow tract (LVOT) for measuring the LVOT diameter. The apical view provided a full standard 2, 3 and 4 chamber view and a depth reduced 2 and 4 chamber view to evaluate the LV ejection fraction (EF) using a modified Simpson's biplane method. Zoomed 4-chamber apical views were obtained to measure medial and lateral mitral annular velocities using tissue Doppler imaging. Apical 2, 3, and 4 chamber views were obtained for longitudinal strain imaging and analysis. Five consecutive ECG gated cardiac cycles were acquired with a frame rate ≥64 frames per second (fps). Images were stored digitally and then transferred to an EchoPac (GE Healthcare, Milwaukee, WI) system for offline 2D and speckle-tracking analyses. Average strain rate for each wall segment as well as a global longitudinal strain were measured. Pulse and continuous wave Doppler images obtained in the 3 and 5 chamber views were obtained for measurements of cardiac output and the myocardial performance index. All valves underwent Doppler interrogation to assess for the presence and severity of any occult valvular disease.

From this set of images, we measured arterial elastance (E_a) (0.9 × systolic blood pressure) / (stroke volume × body surface area) and left ventricular elastance (E_{es}), and LV systolic compliance as previously described [6,7]. Myocardial performance index was also calculated as previously described [8–11].

2.4. Statistical analysis

All analyses were performed using SigmaStat 12.0 and/or SPSS 21.0. The baseline characteristics were compared by one-way ANOVA or χ^2 as appropriate. Correlations between step count, cardiovascular performance measures, and minutes of PA were calculated using Pearson's r. Anthropomorphic measurements, measurements of cardiovascular performance, step count, and time spent in differing levels of PA intensity were compared using general linear models with time (measurements pre- and post-12 week intervention period) as the within subjects factor and randomization assignment as the between subjects factor. Group by time interactions were analyzed for all outcomes. Post hoc testing was performed using Tukey HSD as appropriate. P values of <0.05 are considered statistically significant. The randomized clinical trial in this study is powered based on the primary outcomes of changes in endothelial function by FMD% and arterial stiffness by PWV and the augmentation index [2]. However, based on prior work with respect to E′ [9,12], our study with 26 subjects per group has greater than 90% power to detect a 1.5 cm/s increase in E′ with our intervention at $\alpha = 0.05$.

3. Results

3.1. Baseline demographics

As previously reported, a total of 107 of the enrolled 114 subjects completed the study [2]. The final 5 of the 107 subjects did not have echocardiograms performed due to study financial restraints, leaving a total of 102 subjects available for analyses. There were no significant differences between groups with respect to their sex, age, history of hypertension, smoking status, and history of diabetes. There were also no baseline differences in waist circumference, blood pressure, body mass index, and heart rate (Table 1).

3.2. Changes in baseline demographics by intervention group

Over the 12 week study intervention period, weight ($P = 0.01$), BMI ($P = 0.003$), and waist circumference ($P = 0.009$) decreased for the entire population but did not differ by group assignment. No difference