HHS Public Access
Author manuscript
West J Nurs Res. Author manuscript; available in PMC 2021 July 01.

Published in final edited form as:
West J Nurs Res. 2021 July ; 43(7): 613–621. doi:10.1177/0193945920969422.

Effects of the Intensity of Lifestyle Exercise on Changes in Blood Pressure

Carolyn Harmon Still, PhD, MSM, AGPCNP-BC, CCRP [Assistant Professor],
Frances Payne Bolton School of Nursing, Case Western Reserve University, 2120 Cornell Road, Cleveland, OH 44106-4904

Shirley M. Moore, PhD, RN, FAAN [Emeriti],
Distinguished University Professor, Frances Payne Bolton School of Nursing, Case Western Reserve University, 2120 Cornell Road, Cleveland, OH 44106-4904

Abdus Sattar, PhD [Associate Professor]
School of Medicine, Dept. of Population and Quantitative Health Sciences, Case Western Reserve University, 10900 Euclid Ave, Cleveland, OH 44106

Abstract

The purpose of this study was to investigate whether the amount of time participants exercised in the target heart rate zone (THRZ) influenced change in blood pressure (BP) 1 year following a cardiac event. Lifestyle exercise (habitual, small exercise opportunities) and intensity were objectively measured using portable heart rate monitors. Linear mixed models were used to analyze change in BP among 331 participants. Mean BP at baseline was 118/70 mmHg, and both systolic and diastolic BP increased from baseline to 1 year, 4.79 mmHg (p <.001) and 2.09 mmHg (p =.002), respectively. Overall, participants had a decrease in levels of lifestyle exercise. After controlling for time, age, gender, and study group, SBP change was inversely associated with amount of time in THRZ. Given suboptimal engagement in recommended exercise, the underlying mechanisms of lifestyle exercise effects on the time spent in THRZ to reduce BP warrants further study in this population.

Keywords

Exercise; older adults; blood pressure; cardiovascular disease; target heart rate

---

Cardiovascular disease (CVD) is a leading cause of disability, morbidity, and mortality in the United States and the prevalence of CVD is projected to affect 131 million people by 2035 (Virani et al., 2020). As the population ages, adverse cardiac events (e.g., myocardial infarction, ischemic heart disease, and heart failure) are more common, and one-third of individuals 65 years and older required some type of cardiac surgery (coronary artery

---

*Corresponding author: Phone: 216-368-6338, cwh11@case.edu, Dr. Still, is an Assistant Professor in the Frances Payne Bolton School of Nursing at Case Western Reserve University.

Clinical Trial Registration: ClinicalTrials.gov Identifier: NCT02323919 at https://clinicaltrials.gov/ct2/show/NCT02323919.

Conflict of Interest:
The authors declare that there is no conflict of interest.

bypass, angioplasty) in 2014, costing an estimated $200 billion annually (Odden et al., 2011; Virani et al., 2020). Moreover, high BP (defined as a BP >130/80 mmHg; P. K. Whelton et al., 2017) is a major risk factor for CVD, and affects 48% of the U.S. population and is the leading contributor to poor health outcomes (Virani et al., 2020). A strong body of literature has identified exercise as a key factor for secondary prevention of a cardiac event and BP reduction (Anderson et al., 2016; Smith et al., 2011).

Exercise is defined as a subcategory of physical activity that is planned, structured, repetitive, and purposeful to maintain and improve fitness and is beneficial to health (U.S. Department of Health and Human Services [HHS], 2018). For example, exercise has been shown to significantly reduce all-cause mortality by 33%, as well as increase life expectancy (Byberg et al., 2009; Wen et al., 2011). Other health benefits associated with exercise include improved BP control (P. K. Whelton et al., 2017), weight loss (HHS, 2018), and improved glucose and cholesterol levels (Wright et al., 2018). In addition to exercise, there is considerable scientific evidence that suggest the incorporation behavioral modifications, which can have an additive lowering effect on improving CVD and reducing related risk factors (Chiuve et al., 2006; Shan et al., 2020). Health-promoting behaviors such as adherence to a healthy diet and medication-taking for chronic diseases (e.g., hypertension, hyperlipidemia, diabetes) have been shown to favorably reduce CVD related risk factors by 10% to 27% (Shan et al., 2020; P. K. Whelton et al., 2017). In general, the American Heart Association (AHA, 2018) recommends approximately 30 minutes a day, 5 days a week (2.5 hours/week) of moderate-intensity exercise for the prevention of CVD. Furthermore, optimizing healthy behaviors, including exercise can decrease the likelihood of recurrent CVD events (P. K. Whelton et al., 2017).

Central to secondary prevention of cardiac events and prescribed for most adults recovering from a cardiac event is the participation in an outpatient, phase II cardiac rehabilitation program (CRP; Anderson et al., 2016; Lin et al., 2014). Most CRPs are medically supervised, 12-week exercise programs focused on exercise counseling and training, education on behavior modifications such as the mangement of diet, weight loss, stress, cholesterol, and BP to help improve cardiovascular health after a cardiac event (Anderson et al., 2016). However, CRPs do not emphasize lifestyle exercise to participants. Lifestyle exercise is habitual exercise that incorporates everyday activities from one's daily routine into small exercise opportunities (Lin et al., 2014). Therefore, engaging in lifestyle exercise could be an integral part of secondary prevention of CVD (Smith et al., 2011).

While exercise is important to achieve health benefits, the effects of exercise on health is intensity dependent. One way of assessing exercise intensity is to monitor the target heart rate zone (THRZ; HHS, 2018) defined as the maximum heart rate in a given amount of time in order to reach the level of exertion necessary for cardiovascular fitness, specific to a person's age, sex, or physical fitness (AHA, 2018). The estimated maximum heart rate (220 minus an individuals' age) is most beneficial when an individual engages in moderate-intensity physical activity at 50–70% or vigorous-intensity physical activity at 70–85% of their maximum heart rate during an exercise (Cornelissen & Smart, 2013; HHS, 2018).

Exercise has been a major recommendation for secondary prevention of CVD and the reduction of high BP (AHA, 2018; P. K. Whelton et al., 2017). The relationships between exercise intensity, frequency, duration, and BP response have been studied for decades, yet studies are inconsistent in their conclusions (Cornelissen & Smart, 2013; Costa et al., 2018). A number of studies have found that intensity, duration, and the type of exercise play a significant role in reducing BP (Cornelissen & Smart, 2013; Devereux et al., 2010; Wen et al., 2011). Evidence suggests that isometric exercise can elicit significant reductions in BP when compared with aerobic and resistance exercise (Cornelissen & Smart, 2013; Herrod et al., 2018). Isometric resistance training has the potential to produce BP reductions in both systolic BP, a reduction by 5 mmHg and diastolic BP by 3 mmHg, respectively (Devereux et al., 2010; Herrod et al., 2018). Other research, however, has found that aerobic exercise produce greater BP reduction than isometric exercise (Wen et al., 2011; Moore et al., 2006). However, research is inconsistent regarding which type of exercise (isometric, aerobic, or resistance) can elicit significant reductions in BP (Costa et al., 2018). Such results might be explained by the differences in exercise intensity rather than in the type of exercise (Lamotte et al., 2005). However, such results are limited as they are not conducted in individuals engaging in lifestyle exercise after participating in a CRP. Furthermore, the optimal exercise intensity required to achieve significant BP reduction remains unclear.

Purpose

Current exercise recommendations suggest that individuals with high BP should engage in moderate-intensity physical activity within 40% to ≤60% of their maximum heart rate to reduce BP (AHA, 2018; Pescatello et al., 2015; P. K. Whelton et al., 2017). However, the extent to which a person who engages in lifestyle exercise in their THRZ after a cardiac event reduces BP is unknown. Thus, the purpose of this study was to explore the effect of long-term lifestyle exercise in the THRZ on BP in the year after a cardiac event in older adults. We hypothesized that an increase in the number of hours of lifestyle exercise in the THRZ would result in a greater reduction in BP in older adults in the year following a cardiac event.

Methods

Study Design

The parent study, a lifestyle exercise trial, was a 3-group randomized controlled trial developed to test the effects of two theoretically driven behavior change interventions compared to usual care to improve lifestyle exercise after completion of a CRP, over a 1-year period. Details of this trial have been previously reported and are summarized briefly (Sattar et al., 2017; Wright et al., 2018). The first experimental intervention consisted of contemporary approaches to behavior change, increasing self-efficacy, motivation, problem-solving skills, and relapse management. In the second experimental intervention, participants were taught to use a series of small, self-designed experiments to change their health behaviors. In addition to the usual CRP education, both experimental groups targeted psychoeducational behavior change approaches that consisted of five small-group education sessions provided in three 1.5-hour sessions once a week during the last 3 weeks of the CRP, and two sessions held at 1 and 2 months after the CRP. The Usual Care group consisted of routine care provided by the CRP (Sattar et al., 2017; Wright et al., 2018).

Study Population and Setting

Participants in the parent study consisted of 379 individuals who provided informed consent and met the following inclusion criteria: age ≥ 54 years; experienced a myocardial infarction, coronary artery bypass graft, or angioplasty; resided within a 60-mile radius of the study sites; able to read and speak English; and were enrolled in a phase II CRP. Individuals were excluded if they had concurrent valve surgery, neurological deficits, acute renal failure, pulmonary complications (pneumonia, congestive heart failure), or any obvious musculoskeletal functional disabilities that limited one's ability to engage in lifestyle exercise. In addition, individuals considered high-risk for safe participation in cardiac exercise programs were excluded if they presented with cardiac clinical features such as severe left ventricular dysfunction (ejection fraction < 20%), decrease in systolic BP > 15 mmHg with exercise, serious arrhythmias at rest or exercise-induced, and exercise-induced ischemia > 2 mm of ST depression on the electrocardiogram. Individuals with completed BP data were included in this secondary analysis.

Participants were consecutively recruited from five Phase II CRPs, similar in prescribed CRP-structured exercise, in the Cleveland, Ohio. Individuals meeting inclusion criteria were approached in Week 9 of a 12-week Phase II CRP and recruited over a 2-year period between January 2008 and June 2010. After enrollment, participants were randomized to receive one of the three interventions that begin Week 10 of their CRP. At the end of the CRP, all individuals were given an exercise prescription that included their target heart rate and were counseled to exercise at least 30 minutes per day, 5 days per week. The study's protocol was approved by the University Hospitals Cleveland Medical Center's Institutional Review Board.

Measures

Lifestyle exercise.—Exercise was measured using portable heart rate monitors, Polar RS400 (Polar Electro Inc., Lake Success, NY), while exercise diaries were used as a secondary data source to gain information about the type of exercise and corroborate information about exercise frequency, duration, and intensity. These heart rate monitors provides valid data on heart rate reflecting exercise and has high correlation and agreement with electrocardiographic data (Engström et al., 2012). Participants wore the monitors during all exercise sessions during the study year. If a participant forgot to wear or activate their monitor, daily exercise was recorded in their diary along with the number of minutes and the type of exercise.

The Polar RS400 heart rate monitor has an estimated battery life of 2 years (1 hour/day, 7 days/week) with a memory that can store up to 99 exercise files, and was programmed to record the heart rate at 15-second intervals, for a total of 60 hours (www.polar.com). Heart rate monitors were exchanged monthly to allow close follow-up during long-term data collection and to frequently check the devices for any issues. Participants returned the heart rate monitors monthly by mail after receipt of new heart rate monitors from the study team;

thus, there was no lapse in exercise monitoring. Data was downloaded to a database file monthly using a Polar IR interface and analyzed with Polar software.

Three dimensions of lifestyle exercise (frequency, duration, intensity) were measured. Exercise frequency was the number of sessions exercised monthly and calculated for a total number of exercise sessions over a 1-year period. The duration of exercise was calculated as the total number of 15-second intervals containing an elevated heart rate—from monitored baseline heart rate on the heart rate monitor to the target heart rate achieved—lasting at least 10 minutes. Lastly, exercise intensity consisted of the amount of time the participants exercised in their THRZ, which was calculated prior to completing a CRP. The amount of exercise (number of minutes/session × number of sessions) over the 1-year period was also evaluated.

Target heart rate zone (THRZ).—The THRZ was calculated for each person at the completion of the CRP. Because some of the cardiac rehabilitation centers used in this study did not routinely use exercise testing to calculate the maximum heart rate, we employed two methods to determine the THRZ. For participants without exercise testing data, the age-predicted maximum heart rate formula (220 minus age) was used to calculate the THRZ (Anderson et al., 2016; Tabet et al., 2006). The second method employed was for individuals on medications known to attenuate heart rate response to exercise (e.g., beta-blockers), the Karvonen method ([MHR − resting heart rate] × [training intensity, expressed as a decimal] + resting heart rate) was employed (Diaz-Buschmann et al., 2014).

Blood pressure assessment.—Measures of participants' sitting BP were collected by trained research staff (undergraduate/graduate nursing students and registered nurses). At the time of data collection, the study's protocol for obtaining BP was guided by the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7; Chobanian et al., 2003). BP readings were obtained manually with Welch Allyn aneroid sphygmomanometers. Participants were required to sit still for 5 minutes, with feet flat on floor, before BP was measured (Chobanian et al., 2003). Two BP readings were collected 1 minute apart and then averaged for a final BP reading at baseline and 12-month visits.

Covariates.—A set of covariates (age, sex, race, education, employment status, body mass index [BMI], comorbidities) were self-reported on a demographic questionnaire. These variables were selected based on their known associations with both exercise and BP. Functional capacity was measured using a modified 6-minute walk test (6MWT), which incorporates body weight to improve the prediction of maximal oxygen uptake (Carter et al., 2003). Participants completed the self-report survey on perceived adherence to a cardiac risk reduction regimen using the 20-item Health Behavior Scale (HBS; Miller et al., 1982). The HBS is comprised of five subscales (diet, taking medications, performing activity, stress reduction, and smoking cessation), each with 4-items on a 5-point Likert scale ranging from (1) rarely to (5) almost always performs their prescribe cardiac risk reduction regimen, for a total mean subscale score (Miller et al., 1982). Higher scores are reflective of better adherence to a cardiac risk reduction regimen.

Statistical Analyses

Of the 379 participants enrolled in the parent study, only individuals with complete BP readings (*N* = 331) were selected for this analysis. Descriptive statistics were used to describe the participants' sociodemographic and baseline characteristics. The mean difference between BP at baseline and 1 year was compared using paired t-tests. Additional analyses were performed to compare the difference between individuals who exercised <50% in their THRZ (non-intensity compliant; *n* = 23) vs individuals who exercised 50% or greater in their THRZ (intensity complaint; *n* = 113).

Prior to conducting logistic regression analysis, Spearman's correlation analyses were used to assess the relationships between clinical measures, health behaviors, and BP at baseline. Linear mixed effects models with random intercept were used in studying associations between BP change over 1 year and the amount of time in the THRZ after controlling for age, intervention group, gender, and duration in study (time), with the latter being treated as a random effect. We also considered alternative analyses and compared adjusted and unadjusted models to evaluate and control for covariates (demographic, clinical, and health behavioral measures) that may have significantly affected outcome measure (BP change). For better convergence of the linear mixed effects models across the analyses, we used exchangeable covariance structure for the random effects and Gaussian distribution for errors. We assumed the missing exercise data in the regression models were missing at random. A significance level of .05 (two-sided) was used for all tests. Statistical analyses were performed using Stata 16.0 (StataCorp., 2016).

Results

Descriptive statistics for the participant's baseline and clinical characteristics are shown in Table 1. A total 331 participants were included in this secondary analysis study. Overall, the mean age was 67.07 years (standard deviation [SD] = 7.94 years, range 54 to 89 years) with at least 1.89 (*SD* = 1.63) chronic conditions, and were overweight or obese (*M* = 29.89, *SD* = 5.84). The majority of participants in the sample was male and reported on average, had 15.18 (*SD* = 2.92) years of education. This samples' demographic profile is representative of patients attending a CRP— white male, relatively high levels of education, and income (Ades et al., 2017; Li et al., 2018). Table 2 shows the lifestyle exercise characteristics of the sample—intensity, frequency, duration of exercise, and functional capacity. Results of the mean changes in study variables are presented in Table 3. Overall, mean changes in both systolic BP (SBP) and diastolic BP (DBP) from baseline to 1 year after completion of a CRP increased by 4.80 mmHg ($p < .001$) and 2.12 mmHg ($p = .002$).

Between-group comparison of demographic characteristics for non-intensity compliant (*n* = 218) vs intensity compliant groups (*n* = 113) were only significant for the number of chronic conditions ($p = .039$, data not shown). Both groups showed a significant decrease in levels of exercise (amount and intensity); however, only the intensity compliant group was noted to have a significant increase in SBP ($p < .001$) and DBP ($p = .02$).

Results of Spearman's correlations coefficient indicated that there were significant associations between study variables at baseline. SBP and DBP were positively associated with age ($p < .05$ and $p < .001$). Total time in the THRZ was positively associated with exercise ($p < .001$), functional capacity ($p < .01$), and diet adherence ($p < .01$), while negatively associated with BMI ($p < .01$) and comorbidities ($p < .05$).

In the linear mixed effects models, an increase in SBP was negatively associated with amount of time in the THRZ (β = −0.03, 95% CI: −0.058, −0.001), after adjusting for study time, age, gender, and study groups. The amount of time in the THRZ was not significantly associated with DBP. In another analysis, using linear mixed effects models, including study variables, yielded significant inverse associations between change in SBP and income ($p = .001$) and years of education ($p = .003$: Table 4). This data suggest that increases in SBP were associated with fewer years of education and lower income. Change in DBP was negatively associated with diet adherence ($p = .002$). BMI was positively associated with change in SBP and DBP; one unit increase in BMI was associated with 0.47 mmHg ($p < .001$) and 0.15 mmHg ($p < .05$) increase in SBP and DBP, respectively.

Discussion

The primary purpose of this study was to investigate the effect of exercise time spent in the THRZ on change in BP among older adults 1 year following a CRP. Findings of this secondary analysis study indicate that time in the THRZ is negatively associated with SBP, interpreted as the less time spent in the THRZ, the higher the BP; and that changes in DBP were not associated with time in the THRZ, but were positively associated with BMI.

In the present study, on average, participants exercised 114 hours over a 1-year period and spent an average of 3 hours per month in the THRZ in contrast to current recommendations (150 hour/year or 10 hours/month; AHA, 2018). These results are not surprising and could be partly explained by the downward trend observed in exercise behaviors of clinical and healthy populations (Moore et al., 2006). In one study, Glazer et al. (2013) investigated the relationship between moderate to vigorous physical activity (measured in bouts of ≥10 and <10 minutes) on CVD risk factors in community dwellers. Regardless of short vs. long bouts of physical activity, this study suggest that the accumulated total exercise improved blood lipids, BMI, waist circumference, and Framingham risk score ($p < .001$; Glazer et al., 2013).

Our study found that less time in the THRZ in this study influenced an increase in SBP by approximately 5 mmHg, 1 year following a CRP. This finding is important because an increase in SBP is likely to increase mortality risk (P. K. Whelton et al., 2017; SPRINT Research Group et al., 2015). From a clinical perspective, epidemiological studies indicate that exercise associated with a decrease in BP can have a clinical and meaningful impact (P. K. Whelton et al., 2017). For example, a 2 mmHg reduction in SBP is likely to reduce the mortality associated with stroke by 6% and coronary heart disease by 4%, whereas a reduction of 5 mmHg is likely to reduce the risk of these diseases by 14% and 9%, respectively (P. K. Whelton et al., 2017; S. P. Whelton et al., 2002). The literature also suggests that the association of exercise and BP reduction in individuals with hypertension is more pronounced, and a mean reduction of 7 mmHg for SBP and 5 mmHg DBP are observed and clinically meaningful (P. K. Whelton et al., 2017). In the current analysis, it is important to note that on entry into the study, 96% of the adults were diagnosed with hypertension, and 50% of the study sample had mean SBP <120 mmHg at baseline, while only 9% had SBP greater than 140 mmHg (SBP range 85–170 mmHg).

Moreover, in the current analysis, 84% of the sample were prescribed a beta-blocker antihypertensive, a medication known to reduce resting heart rate and attenuate heart rate response that ultimately affects exercise intensity (Tabet et al., 2006). In one study, Westhoff et al. (2007) found that older adults (mean age 67.8) engaged in aerobic endurance exercise training program, prescribed a beta-blockers heart rate was 18% lower than in the non-beta-blocker group with patients of comparable age. Despite lower heart rates, older adults on beta-blockers demonstrated comparable CVD benefits and BP reduction to those individuals not prescribed a beta-blocker (Westhoff et al., 2007), suggesting that other factors may play a role in the lack of lack of BP reduction in the current study (Tabet et al., 2006). Of note, however, the current analysis did not formally test for differences between those prescribe and not prescribe a beta-blocker antihypertensive due to majority of the current sample prescribed a beta-blocker.

Another important consideration that may influence our study results are potential unmeasured cofounders such as cultural and personnel characteristics, beliefs, self-regulations, stress, and depression, all of which could have a potential impact on the lack of change in exercise and BP that may not be related to the THRZ (McMahon et al., 2020; Park et al., 2014).

In addition, Donlasky et al. (2010) found that the adoption of exercise in cardiac patients were associated with muscle and joint pain, exercise self-efficacy, and abdominal girth; whereas, exercise maintenance was associated with fitness, comorbidities, and race. Thus, assisting individuals to adopt and maintain healthy behaviors remains a major challenge and the effectiveness of exercise programs, however, does not in itself justify their adoption. Importantly, evidence suggest that even after a recent life-threatening cardiac event and participation in 12-week CRP that individuals decrease their level of exercise, in which approximately 15% to 40% of these individuals are exercising 6 months later, and even fewer at 1-year after a CRP (Anderson et al., 2016; Li et al., 2018; Moore et al., 2006).

A strength of this study is that it is one of the first to focus on the objective measure of lifestyle exercises (habitual exercise incorporated into everyday activities that are small exercise opportunities), and the level of exercise in cardiac patients 1 year after a CRP. These data also demonstrate that the effects of exercise are independent of those obtained with other lifestyle behavior modifications (smoking, diet, weight loss). Although findings suggested an negative relationship of exercise on BP, we can postulate that the ongoing benefits of lifestyle exercise can reduce BP. Additional research, however, on lifestyle exercise beyond intensity is needed, and should include relevant factors such as type (i.e., aerobic or resistance), muscles involved, whether the exercise is performed intermittently or continuously, and the time of day when it is performed.

Our study also had a few limitations. First, this is a secondary analysis study, and by design, utilized a predetermined sample, method, and measures. Second, the sample consisted of predominately-White males enrolled in a CRP, which limits the generalization of study results to racial and ethnic minorities who carry the heaviest burden of adverse cardiac events such as myocardial infarction, ischemic heart disease, and heart failure (Virani et al., 2020; P. K. Whelton et al., 2017). In contrast, while the current participation in CRP is about 20% to 30% (Ades et al., 2017), approximately 7% to 11% of racial-ethnic minorities use CRPs (Mead et al., 2016). However, African Americans, Hispanics, and Asians populations are 20%, 30%, and 50%, respectively, less likely to be referred to, participate in, or benefit from CRP (Li et al., 2018). Thus, it is unknown if minorities would have yielded similar findings and our results should be interpreted with those considerations. Lastly, individuals enrolled in this study had lower BPs at baseline and future studies should include a diverse group of participants with uncontrolled BP and compare their results to those who have their BP under control.

In summary, our study demonstrated that less time spent exercising in the THRZ influenced an increase in BP 1 year following a CRP in older adults. Due to suboptimal engagement in recommended exercise, the underlying mechanisms of lifestyle exercise effects on time spent in the THRZ to reduce BP warrants further study in this population.

ACKNOWLEDGEMENTS

This study was funded by a grant from the National Heart, Lung, and Blood Institute, National Institutes of Health (R01HL084767).

References

Ades PA, Keteyian SJ, Wright JS, Hamm LF, Lui K, Newlin K, Shepard DS, Thomas RJ (2017). Increasing cardiac rehabilitation participation from 20% to 70%: A road map from the Million Hearts Cardiac Rehabilitation Collaborative. Mayo Clinic Proceedings, 92(2), 234–242. [PubMed: 27855953]

Anderson L, Oldridge N, Thompson DR, Zwisler AD, Rees K, Martin N, & Taylor RS (2016). Exercise-based cardiac rehabilitation for coronary heart disease: Cochrane systematic review and meta-analysis. Journal of the American College of Cardiology, 67(1), 1–12. 10.1016/j.jacc.2015.10.044 [PubMed: 26764059]

American Heart Association. (2018). American Heart Association recommendations for physical activity in adults and kids. https://www.heart.org/en/healthy-living/fitness/fitness-basics/aha-recs-for-physical-activity-in-adults

Byberg L, Melhus H, Gedeborg R, Sundstrom J, Ahlbom A, Zethelius B, Berglund LG, & Michaelsson K (2009). Total mortality after changes in leisure time physical activity in 50 year old men: 35 year follow-up of population based cohort. BMJ, 338, b688. 10.1136/bmj.b688 [PubMed: 19264819]

Carter R, Holiday DB, Nwasuruba C, Stocks J, Grothues C, & Tiep B (2003). 6-minute walk work for assessment of functional capacity in patients with COPD. Chest, 123(5), 1408–1415. 10.1378/chest.123.5.1408 [PubMed: 12740255]

Chiuve SE, McCullough ML, Sacks FM, & Rimm EB (2006). Healthy lifestyle factors in the primary prevention of coronary heart disease among men: Benefits among users and nonusers of lipid-lowering and antihypertensive medications. Circulation, 114(2), 160–167. 10.1161/CIRCULATIONAHA.106.621417 [PubMed: 16818808]

Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, Jones DW, Materson BJ, Oparil S, Wright JT Jr, Roccella EJ, National Heart, Lung, and Blood Institute Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure, & National High Blood Pressure Education Program Coordinating Committee (2003). The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: The JNC 7 report. JAMA, 289(19), 2560–2572. 10.1001/jama.289.19.2560 [PubMed: 12748199]

Cornelissen VA, & Smart NA (2013). Exercise training for blood pressure: A systematic review and meta-analysis. Journal of the American Heart Association, 2(1), e004473. 10.1161/jaha.112.004473 [PubMed: 23525435]

Costa EC, Hay JL, Kehler DS, Boreskie KF, Arora RC, Umpierre D, Szwajcer A, & Duhamel TA (2018). Effects of high-intensity interval training versus moderate-intensity continuous training on blood pressure in adults with pre- to established hypertension: A systematic review and meta-analysis of randomized trials. Sports Medicine (Auckland, N.Z.), 48(9), 2127–2142. 10.1007/s40279-018-0944-y

Devereux GR, Wiles JD, & Swaine IL (2010). Reductions in resting blood pressure after 4 weeks of isometric exercise training. The European Journal of Applied Physiology, 109(4), 601–606. 10.1007/s00421-010-1394-x [PubMed: 20186425]

Diaz-Buschmann I, Jaureguizar KV, Calero MJ, & Aquino RS (2014). Programming exercise intensity in patients on beta-blocker treatment: The importance of choosing an appropriate method. European Journal of Preventive Cardiology, 21(12), 1474–1480. 10.1177/2047487313500214 [PubMed: 23918838]

Dolansky MA, Stepanczuk B, Charvat JM, & Moore SM (2010). Women's and men's exercise adherence after a cardiac event. Research in Gerontological Nursing, 3(1), 30–38. 10.3928/19404921-20090706-03 [PubMed: 20128541]

Engström E, Ottosson E, Wohlfart B, Grundström N, & Wisén A (2012) Comparison of heart rate measured by Polar RS400 and ECG, validity and repeatability. Advances in Physiotherapy, 14(3), 115–122, 10.3109/14038196.2012.694118

Glazer NL, Lyass A, Esliger DW, Blease SJ, Freedson PS, Massaro JM, Murabito JM, & Vasan RS (2013). Sustained and shorter bouts of physical activity are related to cardiovascular health. Medicine and Science in Sports and Exercise, 45(1), 109–115. 10.1249/MSS.0b013e31826beae5 [PubMed: 22895372]

Herrod P, Doleman B, Blackwell J, O'Boyle F, Williams JP, Lund JN, & Phillips BE (2018). Exercise and other nonpharmacological strategies to reduce blood pressure in older adults: A systematic review and meta-analysis. Journal of the American Society of Hypertension, 12(4), 248–267. 10.1016/j.jash.2018.01.008 [PubMed: 29496468]

Lamotte M, Niset G, & van de Borne P (2005). The effect of different intensity modalities of resistance training on beat-to-beat blood pressure in cardiac patients. European Journal of Cardiovascular Prevention & Rehabilitation, 12(1), 12–17. [PubMed: 15703501]

Li S, Fonarow GC, Mukamal K, Xu H, Matsouaka RA, Devore AD, & Bhatt DL (2018). Sex and racial disparities in cardiac rehabilitation referral at hospital discharge and gaps in long-term mortality. Journal of the American Heart Association, 7(8), e008088. 10.1161/JAHA.117.008088 [PubMed: 29626153]

Lin JS, O'Connor EA, Evans CV, Senger CA, Rowland MG, & Groom HC (2014). Behavioral counseling to promote a healthy lifestyle for cardiovascular disease prevention in persons with cardiovascular risk factors: An updated systematic evidence review for the U.S. Preventive Services Task Force Agency for Healthcare Research and Quality.

Mead H, Ramos C, & Grantham SC (2016). Drivers of racial and ethnic disparities in cardiac rehabilitation use: Patient and provider perspectives. Medical Care Research and Review, 73(3):251–281. 10.1177/1077558715606261 [PubMed: 26400868]

McMahon SK, Lewis B, Oakes JM, Wyman JF, Guan W, & Rothman AJ (2020). Examining potential psychosocial mediators in a physical activity intervention for older adults. Western Journal of Nursing Research, 42(8), 581–592. 10.1177/0193945919871697 [PubMed: 31470769]

Miller P, Johnson NL, Garrett MJ, Wickoff R, & McMahon M (1982). Health beliefs of and adherence to the medical regimen by patients with ischemic heart disease. Heart Lung, 11(4), 332–339. [PubMed: 6919529]

Moore SM, Charvat JM, Gordon NH, Pashkow F, Ribisl P, Roberts BL, & Rocco M (2006). Effects of a CHANGE intervention to increase exercise maintenance following cardiac events. Annals of Behavioral Medicine, 31(1), 53–62. 10.1207/s15324796abm3101_9 [PubMed: 16472039]

Odden MC, Coxson PG, Moran A, Lightwood JM, Goldman L, & Bibbins-Domingo K (2011). The impact of the aging population on coronary heart disease in the United States. The American Journal of Medicine, 124(9), 827–833.e5. 10.1016/j.amjmed.2011.04.010 [PubMed: 21722862]

Park CH, Elavsky S, & Koo KM (2014). Factors influencing physical activity in older adults. Journal of Exercise Rehabilitation, 10(1), 45–52. 10.12965/jer.140089 [PubMed: 24678504]

Pescatello LS, MacDonald HV, Lamberti L, & Johnson BT (2015). Exercise for hypertension: A prescription update integrating existing recommendations with emerging research. Current Hypertension Reports, 17(11), 87. 10.1007/s11906-015-0600-y [PubMed: 26423529]

Sattar A, Josephson R, & Moore SM (2017). Impact of Obesity and other chronic conditions on lifestyle exercise during the year after completion of cardiac rehabilitation. Journal of Cardiopulmonary Rehabilitation and Prevention, 37(4), 262–267. 10.1097/hcr.0000000000000211 [PubMed: 28045720]

Shan Z, Li Y, Baden MY, Bhupathiraju SN, Wang DD, Sun Q, Rexrode KM, Rimm EB, Qi L, Willett WC, Manson JE, Qi Q, & Hu FB (2020). Association between healthy eating patterns and risk of cardiovascular disease. JAMA Internal Medicine, 180(8),1090–1100. 10.1001/jamainternmed.2020.2176 [PubMed: 32539102]

Smith SC Jr, Benjamin EJ, Bonow RO, Braun LT, Creager MA, Franklin BA, Gibbons RJ, Grundy SM, Hiratzka LF, Jones DW, Lloyd-Jones DM, Minissian M, Mosca L, Peterson ED, Sacco RL, Spertus J, Stein JH, Taubert KA, & World Heart Federation and the Preventive Cardiovascular Nurses Association (2011). AHA/ACCF secondary prevention and risk reduction therapy for patients with coronary and other atherosclerotic vascular disease: 2011 update: A guideline from the American Heart Association and American College of Cardiology Foundation endorsed by the World Heart Federation and the Preventive Cardiovascular Nurses Association. Journal of the American College of Cardiology, 58(23), 2432–2446. 10.1016/j.jacc.2011.10.824 [PubMed: 22055990]

SPRINT Research Group, Wright JT Jr, Williamson JD, Whelton PK, Snyder JK, Sink KM, Rocco MV, Reboussin DM, Rahman M, Oparil S, Lewis CE, Kimmel PL, Johnson KC, Goff DC Jr, Fine LJ, Cutler JA, Cushman WC, Cheung AK, & Ambrosius WT (2015). A Randomized Trial of Intensive versus Standard Blood-Pressure Control. The New England Journal of Medicine, 373(22), 2103–2116. 10.1056/NEJMoa1511939 [PubMed: 26551272]

StataCorp. (2016). Stata statistical software: Release 14. College Station, TX: StataCorp LP.

Tabet JY, Meurin P, Ben Driss A, Thabut G, Weber H, Renaud N, Odjinkem N, & Solal AC (2006). Determination of exercise training heart rate in patients on beta-blockers after myocardial infarction. European Journal of Cardiovascular Prevention & Rehabilitation, 13(4), 538–543. 10.1097/01.hjr.0000209813.05573.4d [PubMed: 16874142]

U.S. Department of Health and Human Services. (2018). Physical activity guidelines for Americans (2nd ed.). Author.

Virani SS, Alonso A, Benjamin EJ, Bittencourt MS, Callaway CW, Carson AP, Chamberlain AM, Chang AR, Cheng S, Delling FN, Djousse L, Elkind MSV, Ferguson JF, Fornage M, Khan SS, Kissela BM, Knutson KL, Kwan TW, Lackland DT, … Tsao CW, on behalf of the American Heart Association Council on Epidemiology and Prevention Statistics Committee and Stroke Statistics Subcommittee. (2020). Heart disease and stroke statistics- 2020 update: A report from the American Heart Association. Circulation, 141, e1–e458. 10.1161/CIR.0000000000000075 [PubMed: 31887075]

Wen CP, Wai JP, Tsai MK, Yang YC, Cheng TY, Lee MC, Chan HT, Tsao CK, Tsai SP, & Wu X (2011). Minimum amount of physical activity for reduced mortality and extended life expectancy: A prospective cohort study. Lancet, 378(9798), 1244–1253. 10.1016/s0140-6736(11)60749-6 [PubMed: 21846575]

Westhoff TH, Franke N, Schmidt S, Vallbracht-Israng K, Zidek W, Dimeo F, & van der Giet M (2007). Beta-blockers do not impair the cardiovascular benefits of endurance training in hypertensives. Journal of Human Hypertension, 21(6), 486–493. 10.1038/sj.jhh.1002173 [PubMed: 17330056]

Whelton PK, Carey RM, Aronow WS, Casey DE Jr, Collins KJ, Dennison Himmelfarb C, DePalma SM, Gidding S, Jamerson KA, Jones DW, MacLaughlin EJ, Muntner P, Ovbiagele B, Smith SC Jr, Spencer CC, Stafford RS, Taler SJ, Thomas RJ, Williams KA Sr, Williamson JD, Wright JT Jr. (2017). 2017 ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults A Report of the American College of Cardiology/American Heart Association Task Force on Clinical

Practice Guidelines. Hypertension, HYP.0000000000000065 doi:doi.org/10.1161/HYP.0000000000000065

Whelton SP, Chin A, Xin X, & He J (2002). Effect of aerobic exercise on blood pressure: a meta-analysis of randomized, controlled trials. Annals of Internal Medicine, 136(7), 493–503. [PubMed: 11926784]

Wright KD, Moore-Schiltz L, Sattar A, Josephson R, & Moore SM (2018). Does Lifestyle exercise after a cardiac event improve metabolic syndrome profile in older adults? Journal of Cardiovascular Nursing, 33(3), E1–E9. 10.1097/jcn.0000000000000473

Author Manuscript

Author Manuscript

Author Manuscript

Table 1.

Characteristics of the sample (*N* = 331)

Characteristics	*n* (%)
Age (years)	
55–64 years	133 (40.2)
65–74 years	133 (40.2)
75–84 years	58 (17.5)
> 85 years	7 (2.1)
Male (sex)	240 (72.5)
Race	
White	289 (87.6)
Non-White	41 (12.4)
Marital status	
Married	249 (75.2)
Single	82 (24.8)
Employment	
Employed	153 (46.2)
Unemployed (includes retirees)	178 (53.8)
Income	
<$20,000	23 (7.1)
$20,000–$39,000	74 (23.0)
$40,000-–$79,000	117 (36.3)
>$80,000	108 (33.5)
Insurance	
Medicare	180 (54.5)
Medicaid	6 (1.8)
Private/AARP	305 (92.4)
Out of pocket	143 (43.3)
Non-smoker	323 (97.6)
Diagnosed with hypertension	312 (95.7)
Prescribed a beta-blocker	261 (81.1)

Note: Participants had more than one type of insurance.

Table 2.

Lifestyle exercise characteristics of the sample (*N* = 331)

Characteristics	***Mean***	***SD***	**Range**
Exercise intensity			
Exercised in the THRZ (hours/month)	3.03	4.13	0–24.9
Total THRZ time (hours/12 months)	38.01	53.97	0–323.73
Exercise frequency			
Number of exercised sessions/month	9.38	7.10	0–39.15
Number of exercised sessions/12 months	118.53	93.28	0–509
Exercise duration			
Hours of exercise/month	9.06	7.77	0–42.95
Total exercise time (hours/12 months)	114.80	100.87	0–558.33
Functional capacity, m[a]	1,092.56	299.04	148.5–1,795.0

Abbreviations: THRZ, target heart rate zone.

[a]Using the 6-mintue walk test.

Table 3.

Clinical, health behavioral, and exercise characteristics at baseline and 1 year following cardiac rehabilitation ($N = 331$)

Characteristics	Baseline		1 Year		Mean Difference[†]	95% Confident Limits		*P* value
	Mean	***SD***	***Mean***	***SD***		**Lower**	**Upper**	
Clinical								
Systolic BP, mmHg	118.10	16.04	122.69	15.66	4.80	2.59	7.00	<0.001
Diastolic BP, mmHg	70.22	8.78	71.38	9.57	2.12	0.77	3.48	<0.001
Pulse	79.04	11.72	79.22	12.26	−0.12	−1.56	1.32	0.87
Weight, lbs	194.95	41.05	239.58	179.78	44.63	22.68	66.57	<0.001
Body mass index, kg/m^2	29.45	5.62	29.79	5.86	0.33	0.11	0.55	<0.001
HDL cholesterol, mg/dL	43.24	11.80	47.03	12.90	3.79	2.44	5.13	<0.001
Health behaviors								
Diet adherence[a]	3.99	0.76	3.84	0.81	−0.157	−0.26	−0.05	0.003
Medication adherence[a]	4.94	0.21	4.89	0.35	−0.05	−0.09	−0.01	0.029
Lifestyle exercise characteristics								
Exercised in the THRZ (hours/month)	4.98	6.25	2.59	4.24	−2.38	−3.05	−1.72	<0.001
Number of exercise sessions/month	13.11	8.97	7.95	7.79	−5.16	−6.10	−4.22	<0.001
Hours of exercise/month	11.85	9.55	7.85	8.47	−4.0	−5.02	−2.98	<0.001
Functional capacity, m[b]	1,130.06	293.54	1,163.85	363.34	33.79	4.66	62.91	0.023

Abbreviations: BP, blood pressure; THRZ, target heart rate zone.

[*] The change between baseline and after 1 year of following is significant at 5% significant level.

[†] The mean differences were calculated by averaging the change scores of blood pressure for each participant.

[a] The Health Behavior Scale (HBS) mean subscale scores for both diet and medication adherence range from 1 to 5; higher scores indicate better adherence.

[b] Using the 6-mintue walk test.

Table 4.

Associations between change in blood pressure and the demographic, clinical, and health behavioral characteristics

Outcome Variable	Covariates	Est. of β	SE(β)	95% CI (β)	P value
Systolic BP, mmHg	Employment	0.407	1.605	−2.739, 3.553	0.800
	HDL cholesterol, mg/dL	−0.014	0.081	−0.172, 0.144	0.861
	Body mass index, kg/m^2	0.470	0.126	0.223, 0.718	<0.001
	Functional capacity, m[a]	−0.001	0.003	−0.006, 0.004	0.729
	Smoking[1]	3.328	4.748	−5.977, 12.633	0.483
	Diet adherence[b]	−1.506	0.902	−3.274, 0.261	0.095
	Medication adherence[b]	2.793	2.434	−1.978, 7.564	0.251
	Education, in years	−0.730	0.248	−1.216, −0.243	0.003
	Income	−1.580	0.489	−2.538, −0.621	0.001
	Race[2]	−2.300	2.237	−6.683, 2.087	0.304
	Marital status	−0.549	1.815	−4.107, 3.009	0.762
Diastolic BP, mmHg	Employment	−0.454	0.898	−2.214, 1.307	0.613
	HDL cholesterol, mg/dL	0.039	0.044	−0.049, 0.126	0.386
	Body mass index, kg/m^2	0.145	0.072	0.004, 0.285	0.043
	Functional capacity, m[a]	0.0004	0.002	−0.003, 0.003	0.814
	Smoking[1]	0.798	2.620	−4.338, 5.933	0.761
	Diet adherence[b]	−1.549	0.501	−2.531, −0.568	0.002
	Medication adherence[a]	0.289	1.342	−2.341, 2.920	0.829
	Education, in years	−0.055	0.140	−0.329, 0.220	0.983
	Income	0.126	0.277	−0.416, 0.669	0.696
	Race[2]	0.929	1.251	−1.523, 3.382	0.458
	Marital status	0.372	1.009	−1.606, 2.350	0.712

Note: Using mixed effects models, we controlled/adjusted for study duration (time), age, sex, and intervention group. Each covariate was fit and tested individually for a relationship with blood pressure. Time was modeled as a fixed and random effect. For example, when we study the association between Systolic BP and BMI, we have the following linear mixed model: Systolic BP = $\beta_0 + \beta_1$ BMI + β_2 Time + β_3 Age + β_4 Sex + β_5 Group + $b_0 + b_1$ Time + Errors, where βs are the regression coefficients of the fixed effects. The b_0 and b_1 represent the random intercept and slope of the model. We presented only the coefficient of the covariate of interest, and omitted the coefficients of controlled variables in this Table 4.

[1]Reference was nonsmoker.

[2]Reference was White.

Abbreviations: BP, blood pressure; HDL, high-density lipoprotein.

[a]Using the 6-mintue walk test.

[b]The Health Behavior Scale (HBS) mean subscale scores for both diet and medication adherence range from 1 to 5; higher scores indicate better adherence.