The Effects of Exercise Intensity on Non-Exercise Physical Activity

by

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May 2020

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Cardiometabolic diseases are some of the leading causes of death in the United States with African Americans being at greater risk of mortality from these diseases. Physical inactivity has been shown to be a risk factor for cardiometabolic diseases. Increased levels of non-exercise physical activity has been shown to influence cardiometabolic risk factors. **PURPOSE:** The purpose of the present study is to examine the effects of exercise intensity on non-exercise physical activity. As well as examine the effects of increased levels of non-exercise physical activity on cardiometabolic risk factors. **METHODS:** An all African American sample was recruited and randomized into three groups: control (n=15), moderate-intensity exercise (n=12), high-intensity exercise (n=12). The two exercise groups participated in 24 weeks of aerobic exercise with each group exercising at their assigned intensity. The moderate-intensity group exercised at a HR associated with 50% of their VO_{2max} and the high-intensity group exercised at a HR associated with 75% of their VO_{2max}. Non-exercise physical activity was assessed using a Fitbit Flex that was continuously wore by all participants except during exercise sessions. An analysis of variance (ANOVA) was used to determine if there were between group differences in steps, light-intensity physical activity, and MVPA. To analyze change in steps, light-intensity physical activity, and MVPA and other cardiometabolic risk factors, a pearson's correlation was

utilized **RESULTS:** There were no significant changes in non-exercise physical activity variables and cardiometabolic risk factors between groups but the change in VO_{2peak} was significantly higher in the high-intensity group compared to the control group ($p \leq 0.05$). For the moderate-intensity group, change in fat mass and change in time in vigorous-intensity ($r=-0.61$ $p>.05$) and MVPA ($r=-0.58$ $p<.05$). For the high-intensity group, change in triglycerides and time in vigorous-intensity ($r=0.61$ $p<.05$) and change in glucose and steps ($r=0.58$ $p<.05$) and time in light-intensity ($r=0.65$ $p<0.05$) for high intensity. After splitting the data into tertiles based on change in steps, there was significant between group differences change in steps($p \leq 0.001$), time in light-intensity($p \leq 0.001$), time in moderate-intensity($p \leq 0.01$), time in vigorous-intensity($p \leq 0.01$), time in MVPA($p \leq 0.01$). As well the between group change in weight ($p=0.08$) and BMI ($p=0.083$) approach significant. **CONCLUSION:** In the present study, no compensatory effect of starting a moderate- or high-intensity aerobic exercise was seen on non-exercise physical activity. Additionally, there were benefits to cardiometabolic risk factors with increased levels of non-exercise physical activity, specifically fat mass. Further examination of the effects of non-exercise physical activity on African Americans and other populations is warranted.

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A Thesis

Presented to the Faculty of the Department of Kinesiology

East Carolina University

In Partial Fulfillment of the Requirements for

The Master of Science in Kinesiology

Exercise Physiology Concentration

By

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May 2020

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Chapter I: Introduction

In 2016, cardiovascular disease and type 2 diabetes were the number one and number seven causes of deaths in the United States.[1] Many risk factors have been shown to increase the risk of cardiovascular mortality including hyperglycemia, hypertension, dyslipidemia, obesity, and a sedentary lifestyle.[2,3] Studies have shown that there is a dose-response relationship between physical activity and cardiovascular and all-cause mortality.[4,5] While increasing moderate- to vigorous-physical activity (MVPA) has been shown to improve cardiovascular mortality, recently sedentary behavior has been identified as a risk factor for cardiovascular disease.[6-9]

Independent of MVPA, high levels of sedentary behavior (e.g. sitting time) has been shown to increase cardiovascular mortality.[6-9] Overall our sitting time has been increasing in the United States.[10] For example, since 1950 the average United States household has increased its television watching by 36 minutes every 10 years.[11] This increased sitting time is associated with higher levels of several cardiometabolic risk factors such as obesity, dyslipidemia, hyperglycemia, and hypertension compared to low levels of sitting time.[8,12] Cross-sectional studies have shown that decreasing sitting time decreases these cardiometabolic risk factors.[13-15] This supports the idea that sedentary time, independent of MVPA, should be considered an independent risk factor for cardiometabolic disease.

Replacing sitting time with light-intensity physical activity has been examined as a potential intervention to decrease potential cardiometabolic risk factors. Epidemiological studies have shown that replacing sitting time with light-intensity exercise decreases cardiovascular mortality, independent of MVPA.[12,16] These findings suggest that by increasing light-intensity physical activity could have an effect on cardiometabolic risk factors, independent of MVPA.

With accumulating evidence that displacing sitting time with light-intensity physical activity, independent of MVPA, there is potential that non-exercise physical activity has an effect on cardiometabolic risk factors. Non-exercise physical activity is defined as any physical activity performed outside of structured exercise.[17] Exercise interventions looking at the effects of non-exercise physical activity have shown that increased levels of non-exercise physical activity, independent of MVPA, improved cardiometabolic risk factors such as body composition and glucose tolerance.[2,18,19] Though the exact mechanism is still unclear, more research is needed to understand the effects of non-exercise physical activity on cardiometabolic risk factors.

The purpose of this current study is to examine the effects of exercise intensity on non-exercise physical activity. The study will examine at the effects a moderate-intensity and vigorous-intensity exercise intervention has on participant's non-exercise physical activity. We hypothesize that there will be no change in non-exercise physical activity between different exercise intensity groups. Based on current literature, there is no evidence that there would be any differences between exercise intensity groups.[20] We also hypothesize that participants with higher levels of non-exercise physical activity will have greater changes in body composition, total cholesterol levels, waist circumference, and insulin sensitivity than those with lower levels of non-exercise physical activity. This hypothesis is based on current literature which shows that non-exercise physical activity, independent of MVPA, improves cardiometabolic risk factors.[2,18-20] Through the higher levels of non-exercise physical activity there is potential for higher levels of energy expenditure and increased lipoprotein lipase regulation.[21-23] This study will help increase the knowledge regarding the impact of exercise intensity has on non-exercise physical activity and the effect non-exercise physical activity has on body composition.

Limitations

Limitations of the current study are the use of African Americans only, the use of obese participants, and the use of either moderate-intensity or vigorous-intensity aerobic exercise. Using only obese African American participants, limits the generalizability to other racial groups and weight populations. The generalizability will be limited to only moderate-intensity or vigorous-intensity aerobic exercise and not to other exercise intensities or modalities.

A delimitation of this study is the Fitbit, physical activity monitor that is used by all the participants.

Chapter II: Literature Review

Physical Activity and Mortality

Cardiovascular disease and type 2 diabetes are two of the leading causes of mortality in the United States. Some major cardiometabolic risk factors include hyperglycemia, hypertension, dyslipidemia, obesity, and a sedentary lifestyle.[2,3] In particular, MVPA has been shown in a multitude of studies to play a key role in preventing cardiovascular disease and diabetes.[2-5,10,17,24,25] The current recommendations from the American College of Sports Medicine (ACSM) suggests that adults should participate in a minimum of 30 minutes of moderate-intensity physical activity 5 days per week or 20 minutes of vigorous-intensity physical activity 3 days per week to lower their risk of cardiometabolic disease.[3] This recommendation is supported by epidemiological evidence showing an inverse relationship between high physical activity levels and all cause/cardiovascular mortality.[4,5,25] In general many of these studies support a dose response relationship between level of physical activity and mortality risk.[4,5] Adequate levels of physical activity has been shown to reduce the risk of cardiovascular mortality by 20%-50%.[5,25] For example, in the Nurses' Health Study, Rockhill et al.[5] examined the association between physical activity and mortality. Levels of physical activity were assessed by questionnaire and were reevaluated every 2 to 4 years over a 20 year period.[5] After excluding women with a history of cardiovascular disease or cancer at baseline, 80348 women were included in the analysis.[5] The results of the study suggest that levels of physical activity were inversely associated with all-cause mortality risk ($p<.001$).[5] Also, results showed that the dose-response relationship between level of physical activity and mortality was significant ($p<.0001$).[5] Another finding was that participants who had less than 1 hour per week of physical activity had a 20-31% increase in risk of cardiovascular mortality compared to those that participated in more than

1 hour per week of physical activity (P_{trend}>.001).[5] A moderate mortality risk reduction of 20-25% was shown among women walking less than 1 hour per week with addition of more than 1 hour per week of vigorous activity.[5]

Similarly, in the Harvard Alumni Study by Lee et al.[4] examined the independent association of physical activity and all-cause mortality. Physical activity level (n=17321 males) was assessed using a questionnaire and participants were followed over a 26 year period.[4] The data showed a graded inverse relationship between total physical activity and mortality (p<.001).[4] Men who expended more than 6300 kJ per week in vigorous physical activity had 13-25% lowers risk of all-cause mortality compared to those who expended less than 6300 kJ per week.[4] The difference in mortality risk is approximately at the same magnitude as being 20% or more overweight and being at an ideal weight.[4]

While the previous studies evaluated all-cause mortality, high levels of physical activity have been shown to reduce risk of cardiovascular mortality compared to low levels of physical activity.[5,25] A limitation of the previous studies is that they used only questionnaires to assess physical activity levels instead of an objective measure like accelerometer. To address this limitation, Evenson et al.[25] used accelerometer-assessed physical activity level to determine if there was any difference between the self-reported questionnaires and the objective measures. The data that was used in this study was obtained from NHANES (2003-2006).[25] An Actigraph AM7164 and questionnaires were used to assess MVPA.[25] Participants (n=3809) had to wear the accelerometer for a minimum of 3 days for at least 8 hours/day in order to be included.[25] The results show that the highest level quartile of MVPA have a 50% less risk of cardiovascular mortality than those in the lowest quartile (P_{trend}=0.001).[25]

The above data suggest that MVPA in an independent risk factor for all-cause and cardiovascular disease mortality. Particularly the pursuit of physical activity within the moderate to vigorous range independent of major other independent risk factors such as smoking, hypertension, race and obesity.[5,25]

Sedentary Behavior and Mortality

While physical activity levels and cardiorespiratory fitness are known risk factors for cardiovascular disease, recently the amount of time spent in sedentary time (even in individuals meeting PA guidelines) has emerged as a potential risk factor for all-cause and cardiovascular mortality.[10,17,26] Sedentary behavior is defined as any waking behavior involving little to no energy expenditure (1.0-1.5 METs) while in a sitting or reclining position.[27] It has been found that people spend as much of 50%-60% of their waking hours in sedentary behaviors.[26] Average time spent in sedentary behavior has been found to be 7.7 to 9.5 hours per day.[26-28] People are increasingly spending more time in sedentary behaviors.[10] For example, since 1950 the average United States household has increased its television watching by 36 minutes every 10 years.[11] The amount of television watching has been shown to be the strongest associated sedentary behavior with increased risk of mortality compared to other sedentary behaviors (e.g. sitting in a car, bus, at work, and doing other leisure activities).[8,9]

Several epidemiological studies have found that sedentary behavior is associated with mortality independent of physical activity level.[6-9] People who spent7-12 hours per day in sedentary time had an increased your risk of cardiovascular mortality by 19%-50% compared to those <5 hours per day, independent of MVPA.[6-9] Kim et al.[9] examined the association between total sitting time, time spent performing specific sitting behaviors (e.g. watching TV, sitting in

the car/at work), and all-cause/cardiovascular mortality. The study included 61,395 men and 73,201 women aged 45-75 from the Multiethnic Cohort Study and had a median follow up was 13.7 years.[9] Total sitting time and physical activity were assessed using questionnaires.[9] In this study, sitting ≥10 hours/day compared to <5 hours/day was associated with an increase of 11% in all-cause and 19% in cardiovascular mortality for women but not men, independent of MVPA.[9] However, all leisure time sitting activities were associated with an increased risk in all-cause mortality with TV watching being the strongest risk.[9]

In another epidemiological study, Matthews et al.[8] examined 240,819 adults from the NIH-AARP Diet and Health Study, ages 50 to 71 with no reported cancer, cardiovascular disease, or respiratory disease at baseline. Participants were followed for 8.5 years.[8] Sedentary behaviors and MVPA were assessed using questionnaires.[8] In this study sedentary behaviors included television watching and overall sitting time.[8] Sedentary behaviors were positively associated with mortality ($p<.001$) after adjustment for age, sex, education, smoking, diet, race, and MVPA.[8] Compared those who reported <1 hour of television viewing per day, participants who viewed ≥7 hours per day had nearly twice the risk of cardiovascular mortality (HR: 1.8; 95% CI: 1.5, 2.2).[8] High amounts of television viewing, even with high levels of MVPA (>7 hours per week), was associated with elevated risk of all-cause (HR: 1.4; 95% CI: 1.2-1.7) and cardiovascular mortality (HR: 2.0: 95% CI: 1.3-3.0).[8]

Matthews et al.[7] conducted another epidemiological study examining the difference between physical activity, sedentary behavior, and all-cause mortality. This study used 63,308 participants enrolled in the Southern Community Cohort Study that were ages 40-79 who did not report having heart disease, stroke, cancer, Parkinson's disease, lupus, and multiple sclerosis at enrollment.[7] A questionnaire was used to assess physical activity level and sedentary behavior.[7]

Participants were followed over a 6.4 year period.[7] The results showed, after adjusting for overall physical activity level and other covariates, that spending more time being sedentary (>12 hours/day vs. <5.76 hours/day) was associated with a 20-25% increase in risk for all-cause mortality.[7] Men specifically had a strong positive association between being sedentary (>12 hours/day vs. <5.7 hours/day) and risk of cardiovascular mortality (HR:2.1, 95% CI: 1.3, 3.5, $P_{trend}<0.01$) independent of MVPA.[7]

Katzmarzyk et al.[6] also studied sedentary behaviors and risk of mortality using participants in the Canada Fitness Survey. Baseline data was collected during household visit using a lifestyle questionnaire and physical fitness measures to assess sedentary behavior.[6] Participants (n=7278 males, 9735 females) were followed up for an average of 12 years.[6] After for adjusting for multiple covariates (age, smoking, alcohol consumption, physical activity readiness, and leisure time physical activity), higher levels daily sitting time was associated increased risk of cardiovascular ($P_{trend}<0.0001$) and all-cause ($P_{trend}<0.0001$) mortality.[6] Katzmarzyk et al. also observed a dose-response relationship between sitting time and mortality rates that were similar between those that were inactive ($P_{trend}<0.0001$) and active ($P_{trend}=0.008$).[6] This relationship saw that the highest quintile having a 86% (inactive) and 40% (active) increase of mortality compared to the lowest quintile.[6]

Light-Intensity Physical Activity and Mortality

Outside of exercise and sedentary behavior, light-intensity physical activity also plays a key preventative role independent of MVPA.[10,17] After adjusting for MVPA, lower levels of light-intensity physical activity have been associated with a 23% increase in all-cause mortality.[16] Epidemiological studies have also found that replacing sedentary behavior with

light-intensity physical activity can reduce risk of all-cause and cardiovascular mortality 23% and 24% respectively.[12,16]

Matthews et al.[16] examined the all-cause mortality dose-response for sedentary time, light-intensity physical activity, and MVPA. Accelerometer data (ActiGraph AM-7164) was used to assess light-intensity physical activity, sedentary time, and MVPA.[16] Data was obtained from NHANES and participants were followed up during a 6.6 year follow-up period.[16] Light-intensity physical activity was defined as an activity count of 100-760 or <3 METs.[16] Sedentary time was defined as an activity count of <100.[16] This study showed that those who did 5 hours per day of light-intensity physical activity had a 23% lower risk of mortality (HR: 0.77; 95% CI: 0.6-1.0) than those who only 3 hours per day of light-intensity physical activity after adjusting for MVPA.[16] Also, those who spend 10 hours per day in sedentary behaviors had a 29% greater risk of mortality (HR: 1.29; 95% CI: 1.1-1.5) than those who spent 6 hours per day sedentary behaviors.[16] A major finding of this study was that in less active individuals replacing 1 hour of sedentary with either light-intensity physical activity or MVPA was associated with an 18% and 42% lower mortality, respectively.[16]

Another epidemiological study by Dohrn et al.[12] investigated the effect of replacing sedentary time with light-intensity physical activity on cardiovascular mortality. Participants (n=851) were from the Sweden Attitude Behavior and Change study, wore an Actigraph 7164 accelerometer for at least one day (>10 hours of wear time).[12] Light-intensity physical activity was defined as 100-2019 counts/minute.[12] The study showed that replacing 30 minutes/day of sedentary time with light-intensity physical activity lowered risk of cardiovascular mortality by 24% (HR:0.96; 95% CI: 0.93-0.99).[12] This finding suggests that increasing light-intensity physical activity, independent of MVPA, could have an effect on cardiometabolic risk factors.[12]

Physical Activity and Cardiometabolic Risk Factors

In support of the notion that high sedentary time and low light-intensity physical activity may represent as an independent risk factor for cardiometabolic disease, several researchers have evaluated cross-sectional studies on cardiometabolic risk factors. These studies have shown that higher levels light-intensity physical activity, independent of MVPA, are associated with lower odds of elevated waist circumference[13], elevated metabolic syndrome score[13], lower HDL cholesterol[15], elevated triglycerides[15], and risk of diabetes.[14] Healy et al.[13] examined the associations of objectively measured sedentary time and physical activity through accelerometry with metabolic risk factors in adults without known diabetes from the AusDiab study. Participants (n=169) were given a uniaxial accelerometer (ActiGraph 7164) to measure sedentary and physical activity levels during waking hours for 7 consecutive days.[13] Light-intensity activity was defined as activity counts between 100-1951 per minute.[13] After adjusting for confounding factors (e.g. age, sex, employment status, alcohol intake, income, education, smoking status, diet quality, and family history of diabetes), there was significant independent association of sedentary time, light-intensity time, and mean activity intensity with waist circumference and clustered metabolic risk score.[13] These results suggests that increased metabolic benefits may be obtained by displacing sedentary time with light-intensity activity.[13]

Camhi et al.[15] assessed the relationship between moderate non-exercise physical activity and cardiometabolic health. Moderate non-exercise physical activity was assessed using accelerometer data from NHANES and defined as 760-2019 counts per minute.[15] Participants (n=1371) wore the accelerometer (ActiGraph) for seven consecutive days and had a fasted blood draw to measure HDL cholesterol triglycerides, and glucose.[15] Having a higher moderate non-exercise physical activity, independent of MVPA, was associated with lower odds of elevated

triglycerides (p=0.02), elevated waist circumference (p=0.0006), low HDL cholesterol (p<0.0001), metabolic syndrome (p=0.01), and diabetes (p=0.0005).[15] Having seen these results, it suggests that higher levels of non-exercise physical activity could have an effect on cardiometabolic risk factos.[15]

Another study by Healy et al.[14] measured the effects of light-intensity physical activity, sedentary time, and MVPA on fasting and 2-hour plasma glucose. Actigraph accelerometer data from the AusDiab study was used to determine sedentary time, light-intensity physical activity, and MVPA.[14] An oral glucose tolerance test was evaluated in the participants (n= 67 men, 106 women) to ascertain 2-hour glucose and fasting plasma glucose.[14] Light-intensity physical activity was defined as 100-1951 counts per minute.[14] When adjusted for age, sex, time accelerometer worn, height, waist circumference, accelerometer unit, family history of diabetes, alcohol intake, education, income, smoking status, and MVPA, higher light-intensity physical activity was associated with significantly lower 2-hour plasma glucose than lower levels of light-intensity physical activity(p=0.023).[14]

Changes in Non-exercise Physical Activity Level

With the accumulation of evidence supporting that non-exercise physical activity level is a cardiometabolic risk factor, there is evidence from exercise training studies that non-exercise physical activity may have an effect on cardiometabolic risk factors.[15] Non-exercise physical activity is defined as any physical activity outside of structured exercise sessions.[17] There are several potential mechanisms why non exercise physical activity may lower cardiometabolic risk factors. The most prominent being that there is a cumulative loss of energy expenditure with little to none non-exercise physical activity.[21,22] By sitting for prolonged periods of time,

thousands of intermittent muscle contractions are not occurring thus potentially lowering overall energy expenditure.[21] Another potential mechanism is that lipoprotein lipase regulation is decreased with sedentary behavior.[23] The thought is without exercise, that muscles are not oxidizing fat at the same rate as when they are active.[23] A potential causation for these mechanism is that when adding MVPA into daily life, people decrease non-exercise physical activity and increase sedentary time.[17,22]

A study by Rangan et al.[20] examined if non-exercise physical activity was affected by participating in exercise training. The participants (n=82) were part of the Studies of Targeted Risk Reduction Interventions through Defined Exercise (STRRIDE).[20] Participants were randomized into one of three groups after a four month control period: Aerobic Training (14 kcal/kg body weight per week at 65%-85% peak VO_2), Resistance Training (3 days per week of 3 sets, 8-12 reps per set of 8 different major muscle groups), and a Combination (full aerobic and resistance training protocol).[20] Non-exercise physical activity was measured using a tri-axial RT3 accelerometer worn at the start and end of the control period and during the final week of the exercise training protocol.[20] The results showed no significant difference in the change in non-exercise physical activity between the control period and any of the groups.[20] These results are contrary to the belief that participant will compensate for exercise training by decreasing their non-exercise physical activity.[21,22]

Similarly, Willis et al.[29] examined if there were any compensatory changes in non-exercise physical activity in response to an aerobic training program. The participants (n=91) were obese or overweight sedentary young adults (18-30 years).[29] Participants were randomized into one of three groups: 400 kcal per session, 600 kcal per session, or control.[29] Exercise session were completed 5 days per week for 10 months.[29] The participants were progressed from

150 kcal per session at onset to target energy expenditure by the end of month 4.[29] Non-exercise physical activity was accessed using a uniaxial piezoelectric accelerometer (Actigraph GT1M).[29] The accelerometer was worn over nondominant hip for seven consecutive days at baseline, 3, 5, 7, and 10 months.[29] The accelerometer data for the exercise sessions was removed over the duration of that exercise session.[29] The results showed there were no significant effects of group, time or group-time interaction with non-exercise physical activity (all $p>0.05$).[29]

A few exercise training studies have examined the how non-exercise physical activity effects cardiometabolic risk factors.[2,18,19] These exercise training studies have shown higher levels of non-exercise physical activity leads to larger decreases in waist circumference[18], weight[18], total cholesterol[19], and 2-hour oral glucose tolerance.[2] Swift et al.[18] examine how non-exercise physical activity affected waist circumference and weight within exercise training groups. Participants (n=325) were sedentary postmenopausal women from the Dose Response to Exercise in Women (DREW) study and were randomly assigned to one of four groups: control, 4 kcal/kg per week, 8 kcal/kg per week, and 12 kcal/kg per week.[18] Each exercise program was conducted for 6 months.[18] The participants wore an Accusplit Eagle AE1620 pedometer for the entirety of the intervention.[18] Non-exercise physical activity was assessed by the pedometers that were only worn outside of the exercise training protocol.[18] The study showed that higher levels of non-exercise physical activity resulted in a greater change in waist circumference (-4.2 cm vs, -1.0cm; $p_{trend}<0.001$) and weight (-2.0kg vs -1.0kg; $p_{trend}=0.03$) than lower levels of non-exercise physical activity independent of dose of exercise.[18]

A second study by Di Blasio et al.[19] determined if there was difference in non-exercise physical activity in participants that were part of an aerobic exercise protocol and the effects it had on aerobic training-related adaptations. Participants (n=34 postmenopausal women) were put

through a 13-week walking training program (4 days/week 40-50 minutes of moderate intensity).[19] Non-exercise physical activity was determined by two axis accelerometer (SenseWear Pro_2) worn over 3 consecutive days.[19] During the study two distinct groups appeared, one that increased non-exercise physical activity and one that decreased non-exercise physical activity.[19] Those with an increase in non-exercise physical activity saw a reduced LDL-cholesterol ($F_{1,17}$=4.19; P=0.05) and total cholesterol ($F_{1,17}$=5.89; P=0.027) compared to those with a decrease in non-exercise physical activity.[19]

Kozey-Keadle et al.[2] examined if the combination of exercise training and reducing sedentary time resulted in greater changes in health markers than either intervention alone. Overweight/obese participants (n=19 males, 39 females) were randomly assigned one of four 12-week programs: exercise (EX), reducing sedentary time (rST), combination (EX-rST), and control (CON).[2] Fasting lipids, blood pressure, peak oxygen uptake, BMI, and 2-h oral glucose tolerance tests were completed pre- and post-intervention.[2] Non-exercise physical activity was determined by an activPAL wore at baseline and weeks 3, 6, 9, and 12 of the intervention period.[2] During the study, rST and EX-rST groups significantly reduced sedentary by 7% (~50 minutes/day) and 10.3% (70 minutes/day) respectively.[2] The EX-rST also significantly improved composite insulin-sensitivity index 17.8% (p=<0.05), decreased 2-hour insulin by 33.3% (p=<0.01), and decreased insulin area under the curve by -19.4% (p=<0.01).[2] Though there was no significant changes in the rST group, the findings from the EX-rST group suggest that increasing non-exercise physical activity with exercise training may have metabolic benefits that are not seen in just exercise alone.[2]

Limitations of the current research are that they do not study how exercise intensity effects non-exercise physical activity. Also, the exercise interventions were relatively short in

length, with only one going longer than 13 weeks.[2,18,19] More research should be done to see the long-term effects of non-exercise physical activity on cardiometabolic risk factors. There is also, not much research directly examining how non-exercise physical activity effects body composition.

Summary

In conclusion, non-exercise physical activity has been shown to have an effect on cardiometabolic risk factors independent of MVPA.[2,18,19] As a result, non-exercise physical activity should be considered a separate cardiometabolic risk factor. Further research is needed to define the effects of non-exercise physical activity on other cardiometabolic risk factors. It has been shown that different types of exercise can influence non-exercise physical activity however, more research needs to be done to see further investigate how non-exercise physical activity changes with exercise intensity.

Chapter 3: Methods

The purpose of this present study is to: 1) compare the effects of moderate- and vigorous-intensity aerobic exercise on non-exercise physical activity and 2) determine if changes in non-exercise physical activity are associated with changes in other cardiometabolic risk factors. Data from this present study was obtained from the High Intensity exercise to Promote Accelerated improvements in Cardiorespiratory Fitness (HI-PACE). The primary purpose of the HI-PACE study was to determine the effect of exercise intensity on cardiorespiratory fitness and insulin sensitivity in obese African Americans. The HI-PACE methodology was reviewed and approved by the East Carolina University Institutional Review Board. Written informed consent was obtained for each participant prior to study enrollment.

Participants

Utilizing flyers, website and newspaper advertisements, and email distribution, 60 participants were recruited. Inclusion criteria included African American participants, age 40-65 years, and classified as overweight or obese (30.0-45.0 kg/m^2). African American race was established by self-report. Exclusion criteria includes diagnosis of type 2 diabetes (blood glucose value >125 mg/dL), known cardiovascular diseases, unsafe high resting blood pressure (systolic > 180 mmHg; diastolic > 100 mmHg), life threatening conditions, pregnancy or planned pregnancies, significant medical conditions/diseases, current engagement in dietary or weight loss interventions, and non-adherence to study protocols.

Participant Screening

Screening was performed with both a web screen and telephone interview, where a study staff member would screen for major aspects of the inclusion and exclusion criteria as well as provide additional information about study participation. Eligible participants would then be invited to a one-on-one orientation session with the research coordinator to further discuss procedures, study design, and associated risks and benefits. Participants interested in enrolling provided informed consent. The research coordinator then screen participants for full study inclusion/exclusion criteria, collect contact/demographic information, and review prescribed medications. Screening measurements taken included: resting blood pressure, BMI, and waist circumference. Blood was also drawn and sent to a clinical laboratory for lipid, glucose, insulin analyses, and a comprehensive metabolic panel. Baseline physical activity levels was assessed using accelerometry measured by a Fitbit Flex (Fitbit Inc., San Francisco, CA) for 7 days. The complete flow of the procedures can be seen in Figure 1.

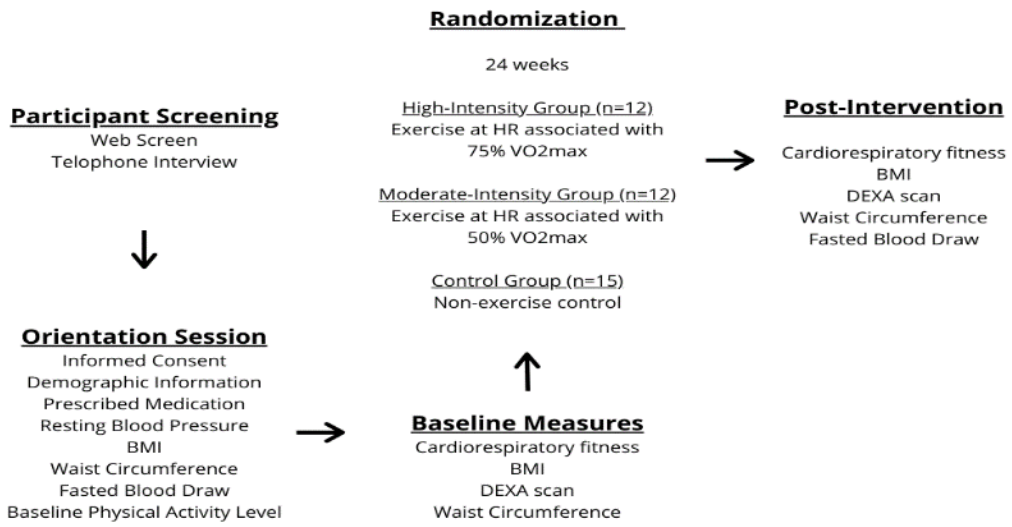

Figure 1. Flow of HI-PACE Study

Baseline and Follow-Up Assessment

Baseline measurements including cardiorespiratory fitness, BMI, DEXA, and waist circumference were assessed. These measures were re-assessed at the end of the 24-week intervention.

To determine body mass index (BMI in kg/m^2), body weight was measured using a Digi Tol calibrated scale (Mettler Toledo, Columbus, OH). Height was measured by utilization of a height rod on a balanced scale. Body fat percentage was measured by dual energy x-ray absorptiometry (DEXA) (GE Lunar Prodigy Advance, Fairfield, CT). Participants were asked to remove all jewelry and shoes, positioned properly on the DEXA machine, and instructed to lie motionless on the DEXA machine until scan completion. Waist circumference was measured at the natural waist (inferior border of the rib cage, superior aspect of the iliac crest) via a Gulick tape measure.

A blood sample was drawn with the participant in a fasted state at baseline and follow-up. A total of 21 mL of blood was drawn by the study nurse and was immediately sent to a clinical laboratory (LabCorp Inc.) for a complete metabolic panel, lipid panel, insulin level, and blood chemistries.

For the present study non-exercise physical activity is defined as any physical activity done outside of the prescribed exercise intervention. Non-exercise physical activity data was monitored in all groups using a Fitbit Flex activity tracker throughout the 24-week intervention period. Each group was blinded to the number of steps accrued via taped cover and instructed to not consciously change their non-exercise physical activity levels from baseline. Prior to each exercise session, the Fitbit device was removed from the participant and uploaded to the Fitbit software. This is done in order to not mix exercise and non-exercise physical activity data.

Participants in the non-exercise control group would sync their data at home using the Fitbit software and be monitored by study staff to assure compliance. Surveys were emailed 3 times per week to all participants to inquire about Fitbit wear. This process helped to ensure consistent daily wearing of the device and to determine if the participant did not wear the Fitbit for extended periods of time – which was designated as invalid data (e.g. >4 hours of non-wear, <1000 steps/day).

Study staff used a database program (Fitabase, Small Steps Labs, San Diego, CA) to centralize all non-exercise physical activity data, inclusive of total daily steps, minutes of light, and moderate and vigorous physical activity

Study Procedures

Participants were randomized into either the moderate intensity (n=12), high intensity (n=12), or non-exercise control group (n=15) for a period of 24 weeks. Participants, who were randomized into one of the exercise groups, engaged in supervised exercise 3-4 days/week on a treadmill to maintain control of energy expenditure.

The moderate-intensity group exercised at a heart rate associated with 50% , while the high-intensity group exercised at a heart rate associated with 75% VO_{2max}. Both groups accumulated 600 MET-minutes/week which corresponds with current PA guidelines (500-1,000 MET-minutes/week). Both groups exercised at 300 MET-minutes during week 1. Each week, the volume of exercise was increased by 50 MET-minutes until the 600 MET-minute level was achieved by week 7. MET-minutes were calculated via ACSM equations based on treadmill speed and grade, and participant weight.

At the first session of each week the participant's weight was taken. Also, a medication check was given to the participant to determine if there were any changes in medication usage.

During the medication check the participant was also asked if they are participated in any other exercise or diet program, if there was a deliberate change in their non-exercise physical activity, and if they have had any adverse symptoms (dizziness, nausea, chest pain, etc.).

Participant heart rate was continuously monitored by use of Zephyr Bioharness 3 monitors (Annapolis, MD) to monitor and ensure appropriate exercise intensities for each group. Following exercise, heart rate data was downloaded to a computer. The start and end of an exercise session was timestamped to determine average heart rate for the entire exercise session.

Statistical Analysis

Baseline values for continuous variables were accumulated and reported in means and standard deviations. Baseline continuous variables were assessed using a one-way analysis of variance (ANOVA). To determine if differences existed for baseline categorical values a chi square analysis was conducted. A Pearson's correlation was ran to determine the relationship between baseline steps and demographic factors. Change scores were calculated for all dependent variables and the change score for each variable was used in all subsequent analyses. Participants with any missing data for the cardiometabolic risk factors excluded from analysis. Non-exercise physical activity data was imputed for any missing weeks.For the first hypothesis, an analysis of variance (ANOVA) was used to determine if there were between group differences in steps, light-intensity physical activity, and MVPA. For our second hypothesis to analyze change in steps, light-intensity physical activity, and MVPA and other cardiometabolic risk factors (body fat percentage, insulin sensitivity, triglycerides, and total cholesterol levels), a pearson's correlation was utilized with an alpha level of <0.05. The data was split into tertiles based off change in steps to see if there was a difference in effect on the cardiometabolic risk

factors. An ANOVA was used to compare these tertiles. Statistical significance was set at alpha <0.05

Chapter IV: Results

Baseline characteristics are summarized for each study group in Table 1. Each group contained the following amounts of participants: control n=15, moderate-intensity n=12, and high-intensity n=12. The mean BMI of the study population was 34.47 kg/m^2 and the mean VO_2 was 20.00 $mL \cdot kg^{-1} \cdot min^{-1}$. There were no significant differences observed between the group means for age, sex, weight, BMI, waist circumference, body fat percentage, lipid measurements, glucose, insulin, average step count, time in light-intensity, time in moderate-intensity, time in vigorous-intensity, and time in MVPA at baseline (Table 2). At baseline steps was correlated with BMI ($r=-0.36$, $p\leq0.05$), fat mass ($r=-0.21$, $p\leq0.05$), and VO_{2peak} ($r=0.51$, $p\leq0.01$).

The mean change scores for each cardiometabolic risk factors and non-exercise physical activity for each group are shown in Table 3. There were no significant changes in non-exercise physical activity variables and cardiometabolic risk factors between groups but the change in VO_{2peak} was significantly higher in the high-intensity group compared to the control group ($p\leq0.05$).Further, the change in triglycerides between moderate-intensity and high-intensity groups approached significance ($p=0.064$).

Looking at the changes in each group individually there were a few correlations between non-exercise physical activity and cardiometabolic risk factors (Table 4). For the control group, there was a significant correlation between the change in LDL and change in steps ($r=-0.67$ $p<0.01$) and time in light-intensity ($r=-0.69$ $p<.01$). For the moderate-intensity, change in fat mass and change in time in vigorous-intensity ($r=-0.61$ $p>.05$) and MVPA ($r=-0.58$ $p<.05$). For the high-intensity group, change in triglycerides and time in vigorous-intensity ($r=0.61$ $p<.05$) and change in glucose and steps ($r=0.58$ $p<.05$) and time in light-intensity ($r=0.65$ $p<0.05$) for high intensity.

To focus specifically on the exercise responses, we evaluated the relationship between non-exercise physical activity variables with cardiometabolic risk factors in the participants in the exercise intervention groups. For exercisers there was no correlation between the change in non-exercise physical activity and the change in cardiometabolic risk factors.

The data was split into tertiles based on change in steps to examine the relationship between a change in steps and the change in cardiometabolic risk factors. The tertiles were split as follows: group 1 Δsteps=-4000 to -1000 (n=12), group 2 Δsteps=-1000 to 250 (n=14), group 3 Δsteps= 250 to 3500+ (n=13). At baseline (Table 5), there were significant differences in steps($p \leq 0.01$), time in light-intensity ($p \leq 0.01$), and glucose ($p < 0.05$) (between which groups). In the tertile change scores (Table 6) there was significant between group differences change in steps($p \leq 0.001$), time in light-intensity($p \leq 0.001$), time in moderate-intensity($p \leq 0.01$), time in vigorous-intensity($p \leq 0.01$), time in MVPA($p \leq 0.01$). As well the between group change in weight ($p=0.08$) and BMI ($p=0.083$) approach significant.

Chapter V: Discussion

Multiple epidemiological studies have shown that low levels of sedentary behavior decrease cardiovascular and all-cause mortality even in adults who are meeting the physical activity guidelines.[6-9] Obese individuals are more likely to not meet physical activity recommendations and be more sedentary than leaner individuals.[6] Several epidemiological studies have shown that replacing sedentary time with light-intensity activity had a reduction in cardiometabolic risk factors.[13-15] It is theorized though that people who start exercise training programs potentially compensate by decreasing non-exercise physical activity.[17,22] However, there is little data that has compared the impact of two distinct exercise training intensities (moderate vs. vigorous). In addition, potential for changes in non-exercise physical activity has not been evaluated in obese African Americans (who have elevated CVD risk compared to Caucasians).

The primary findings of the present study are that in a group of obese African Americans were observed no changes in non-exercise physical activity occurred in response to moderate or high intensity aerobic exercise training. However, those that did change their non-exercise physical activity saw positive changes to their cardiometabolic risk factors, specifically fat mass. This suggests that exercise training at moderate or high intensity exercise (in compliance with physical activity guidelines) does not result in compensatory changes in non-exercise physical activity. In addition, there were some positive changes to cardiometabolic risk factors when non-exercise physical activity was increased.

A novel aspect about our study is that we evaluated changes in non-exercise physical activity in health disparity population, which have not been reported in a published study to our knowledge. In studies of mostly Caucasian samples (or studies where race was not specifically

defined[20,29]) aerobic exercise training did not change non-exercise physical activity. The HI-PACE study supports the finding of those studies, as we found no significant change in non-exercise physical activity during an exercise intervention. Willis et al.[29] in a 10 month aerobic training study reported that there were no changes in in non-exercise energy expenditure, assessed through accelerometerty (ActiGraph) worn at baseline, 3.5, 7, and 10 months, between controls, a 400 kcal/session, and a 600 kcal/session group (exercised at 70-80% HR_{max}), which would approximate higher intensity aerobic training Similarly, the authors reported no change in time in light-, moderate-, or vigorous-intensity physical activity ($p>0.05$).[29] Furthermore, Rangan et al.[20] in the STRIDDE AT/RT study observed no change in non-exercise physical activity energy expenditure measured via accelerometry between an aerobic training (1.6± 57.0; 14 kcal/kg body weight per week at 65%-85% peak VO_2 [range: moderate to high intensity]), a resistance training (-1.8±44.4), and a combination group (19.1±61.7), even though the combination group had significantly more exercise energy expenditure. Thus, the present study, as other previous studies as well, support that there are no group-based changes in non-exercise physical activity variables in response to exercise training. Therefore, in general terms, participation in aerobic exercise training according to PA guidelines does not appear to result in major compensatory changes.

Although, we did not observe changes in non-exercise physical activity, we performed additional analyses to evaluate changes in risk factors across the magnitude of change of non-exercise PA. Recently, there has been the suggestion that decreases in non-exercise physical activity level with aerobic exercise training could attenuate improvements in cardiometabolic risk factors. When it comes to increased levels of non-exercise physical activity, previous studies suggest that higher levels of non-exercise physical activity can have an effect on cardiometabolic

risk factors, such as LDL cholesterol, total cholesterol, weight, waist circumference, and 2-hour glucose tolerance.[2,18,19] For example, DiBlasio[19] et al. saw in a 13 week walking program found the higher levels of non-exercise physical activity decreased LDL and total cholesterol As well, Swift et al.[18] in a 6 month aerobic exercise intervention reported that higher levels of non-exercise physical activity resulted in a greater change in waist circumference and weight between the lowest and highest tertile. These changes were not found in the current study though there was a significant correlation between the change in fat mass and change in time in vigorous-intensity for the moderate-intensity group. A potential reason that the results of this current study are not similar to DiBlasio et al. and Swift et al. is that demographics of the current study are quite different. Both previous studies used participants that were all postmenopausal women and primarily Caucasian. Swift et al. reported their participants were 28% African American. For the current study, all participants were African American and 76% female. With the changes seen in non-exercise physical activity seen in this present study there is some suggestion that increasing non-exercise physical activity could improve cardiometabolic risk factors.

A limitation of this current study is the use of commercial grade accelerometers. Sushames et al.[30] compared the validity and reliability of the Fitbit Flex and Actigraph and the results indicated that Fitbit Flex had moderate validity: where the Fitbit flex tended to undercount steps and averaged lower levels of MVPA [30] Though the Fitbit Flex could be useful in a real-life setting, this may have reduced the accuracy of our measurement of non-exercise physical activity. Another limitation of the current study is that this was a randomize clinical trial with high level of support to ensure high compliance to aerobic training. Further studies should investigate a similar trial in an effectiveness setting. Furthermore, the sample size for the current study was low, which lead to spurious correlations in the high intensity group. These correlations

were change in glucose and change in steps, change in glucose and change in time in light-intensity, change in triglycerides and change in time in vigorous-intensity, and change in fitness and change in time in vigorous-intensity. This may be due to a couple of outliers in the change in glucose and change in steps and time in light intensity pulling the correlation in the opposite direction that was excepted. When these outliers were removed from these and reanalyzed the direction of the correlation flipped. In a larger sample size, there might be a more discernible effect seen.

The main strength of this study is that wear time of the accelerometer was continuous throughout the whole intervention. Previous studies[2,19,20,29] only had participants wear accelerometers for multiple time points during the intervention. Only 1 study[18] to our knowledge tracked participant's non-exercise physical activity continuously[18], but that was only through pedometers. Another strength of this study was that it was performed in an all African American sample. Previous studies were done on unknown racial demographics[20,29], low percentage of African Americans (28%)[18] or postmenopausal women[18,19]. This is important given the increased risk in cardiovascular disease and type 2 diabetes in African Americans.

In conclusion, the present study suggests that starting an aerobic training program does not change non-exercise physical activity in obese African Americans. Also, that there is potential benefit to increase non-exercise physical activity on cardiometabolic risk factors. The major public health implications of the present study is that there was no observed compensatory effect of starting either a moderate or high intensity exercise program on non-exercise physical activity. The results from the present study suggest that clinicians do not need to worry about people compensating an exercise program by increasing sedentary time

Further study should be done investigating the effects on non-exercise physical activity on cardiometabolic risk factors within other populations such as those already with chronic diseases and older adults. Additionally, future studies should evaluate potential compensatory effects of other training modalities (e.g. resistance training, interval training, group fitness classes). As well, further studies should investigate larger changes in non-exercise physical activity (e.g. purposefully increasing non-exercise physical activity). This will allow insight in to whether non-exercise physical activity has any true effect on cardiometabolic risk factors. Within this current study and previous studies there seems to between a correlation between increased non-exercise physical activity and risk factors.

Table 1: Baseline Characteristics

	Control (n=15)	Moderate Intensity (n=12)	High Intensity (n=12)
Age (yrs.)	49.00 ± 5.66	50.92 ± 7.74	48.38 ± 9.27
Gender (% female)	76.92	75	76.92
Weight (kg)	91.53 ± 17.58	98.71 ± 13.07	101.17 ± 18.69
BMI (kg/m^2)	32.61 ± 6.02	35.24 ± 4.87	36.02 ± 5.85
Waist Circumference (cm)	93.88 ± 11.91	97.80 ± 8.80	103.08 ± 13.51
Body Fat (kg)	37.09 ± 14.1	42.32 ± 10.47	42.63 ± 10.95
HDL Cholesterol (mg/dL)	52.33 ± 11.26	54.83 ± 14.59	51.50 ± 16.30
LDL Cholesterol (mg/dL)	114.13 ± 24.91	113.00 ± 42.74	97.58 ± 21.94
Total Cholesterol (mg/dL)	186.67 ± 28.05	184.00 ± 42.64	170.33 ± 28.70
Triglycerides (mg/dL)	100.93 ± 48.50	80.83 ± 24.72	105.67 ± 43.52
Glucose (mg/dL)	92.67 ± 8.34	93.25 ± 7.59	93.42 ± 8.82
Insulin (uIU/mL)	13.56 ± 7.68	16.06 ± 10.22	16.33 ± 8.41
VO_{2peak} $(mL \cdot kg^{-1} \cdot min^{-1})$	21.79 ± 6.23	18.67 ± 4.71	19.10 ± 4.3
Average Step Count	6445.3 ± 3046.6	6662.9 ± 2181.4	7321.5 ± 3399.5
Time in Light Intensity (min)	238.88 ± 75.51	231.93 ± 59.16	264.97 ± 61.97
Time in Moderate Intensity (min)	9.72 ± 14.54	10.14 ± 6.24	10.32 ± 15.95
Time in Vigorous Intensity (min)	2.09 ± 3.78	4.08 ± 6.24	3.05 ± 4.55
Time in MVPA (min)	11.81 ± 18.17	13.88 ± 14.27	13.38 ± 20.19

No significant differences between groups

Table 2: Change in Intervention Factors

	Control	Moderate Intensity	High Intensity
Δ Weight (kg)	0.88 ± 3.62	0.34 ± 3.42	-0.04 ± 3.21
Δ BMI (kg/m^2)	0.36 ± 1.3	0.14 ± 1.19	0.04 ± 1.25
Δ Waist Circumference (cm)	-1.09 ± 4.31	1.09 ± 5.67	-0.60 ± 2.29
Δ Body Fat (kg)	0.38 ± 1.96	0.21 ± 3.01	-1.16 ± 3.43
Δ HDL Cholesterol (mg/dL)	-4.13 ± 7.03	-1.33 ± 5.19	0.67 ± 5.97
Δ LDL Cholesterol (mg/dL)	-7.12 ± 14.28	-0.67 ± 15.09	1.53 ±18.66
Δ Total Cholesterol (mg/dL)	-11.00 ± 19.36	-1.00 ± 19.56	-2.25 ± 21.82
Δ Triglycerides (mg/dL)	-8.87 ± 23.89	5.00 ± 19.48+	-16.25 ± 20.89+
Δ Glucose (mg/dL)	-1.87 ± 8.86	-2.33 ± 6.41	-2.33 ± 8.41
Δ Insulin (uIU/mL)	-2.66 ± 5.50	-2.66 ± 9.59	-2.85 ± 6.84
Δ VO_{2peak} ($mL \cdot kg^{-1} \cdot min^{-1}$)	-0.77 ± 2.91*	1.82 ± 2.84	2.68 ± 2.59*
Average Δ Step Count	-35.9 ± 1169.8	-633.4 ± 1236.6	-703.7 ±1753.1
Δ Time in Light Intensity (min)	-17.30 ± 44.43	-16.47 ± 42.08	-30.61 ± 49.02
Δ Time in Moderate Intensity (min)	0.08 ± 5.05	-4.07 ± 6.30	-1.41 ± 11.63
Δ Time in Vigorous Intensity (min)+	1.42 ± 3.40+	-1.35 ± 4.03+	-0.71 ± 2.48
Δ Time in MVPA (min)	1.53 ± 8.10	-5.09 ± 8.95	-1.95 ± 13.48

*Change in VO_{2peak} was significant between Control and High-Intensity groups (p=0.008)
+ Change in triglycerides between Moderate- and High-Intensity (p=0.055) and change in time in Vigorous-Intensity between Control and Moderate-Intensity (p=0.099) approached significance

Table 3: Non-Exercise Physical Activity and Cardiometabolic Risk Factor Correlations

Moderate-Intensity Group	Δ Step Count	Δ Time in Light Intensity (min)	Δ Time in Moderate Intensity (min)	Δ Time in Vigorous Intensity (min)	Δ Time in MVPA (min)
Δ Weight (kgs)	0.04	0.15	-0.17	-0.40	-0.38
Δ BMI (kg/m^2)	0.03	0.17	-0.18	-0.42	-0.39
Δ Waist Circumference (cm)	-0.42	-0.16	-0.08	-0.17	-0.21
Δ Body Fat (kg)	-0.09	0.11	-0.35	-0.61*	-0.58*
Δ HDL Cholesterol (mg/dL)	-0.30	-0.32	0.02	0.22	0.20
Δ LDL Cholesterol (mg/dL)	-0.31	-0.18	-0.16	-0.12	-0.08
Δ Total Cholesterol (mg/dL)	-0.43	-0.29	-0.21	-0.11	-0.11
Δ Triglycerides (mg/dL)	-0.44	-0.33	-0.47	-0.36	-0.49
Δ Glucose (mg/dL)	-0.06	-0.39	0.27	0.28	0.29
Δ Insulin (uIU/mL)	0.51+	0.19	0.31	0.22	0.26
Δ VO_{2peak} $(mL \cdot kg^{-1} \cdot min^{-1})$	0.08	-0.14	0.19	0.46	0.37

High-Intensity Group	Δ Step Count	Δ Time in Light Intensity (min)	Δ Time in Moderate Intensity (min)	Δ Time in Vigorous Intensity (min)	Δ Time in MVPA (min)
Δ Weight (kgs)	0.24	0.15	0.05	0.18	0.06
Δ BMI (kg/m^2)	.23	0.13	0.18	0.18	0.07
Δ Waist Circumference (cm)	-0.09	0.10	-0.40	-0.27	-0.39
Δ Body Fat (kg)	0.15	0.05	0.01	0.13	0.02
Δ HDL Cholesterol (mg/dL)	0.17	0.03	0.26	0.37	0.26
Δ LDL Cholesterol (mg/dL)	0.22	0.42	-0.23	-0.02	-0.21
Δ Total Cholesterol (mg/dL)	0.25	0.30	-0.05	0.19	-0.03
Δ Triglycerides (mg/dL)	0.25	0.01	0.40	0.61*	0.44
Δ Glucose (mg/dL)	0.58*	0.65*	0.13	0.12	0.15
Δ Insulin (uIU/mL)	-0.14	-0.32	0.11	0.21	0.12
Δ VO_{2peak} $(mL \cdot kg^{-1} \cdot min^{-1})$	-0.40	-0.13	-0.45	-0.67*	-0.49

*Significant at $p \leq 0.05$ +Approached significance ($p \leq 0.1$)

Table 4: Tertile Baseline Characteristics

	Group 1 (n=12)	Group 2 (n=14)	Group 3 (n=13)
Weight (kgs)	94.05 ± 18.37	99.48 ± 14.62	96.17 ±18.37
BMI (kg/m^2)	33.79 ± 5.86	34.85 ± 4.56	34.68 ± 6.94
Waist Circumference (cm)	96.28 ± 14.38	98.05 ± 10.60	99.30 ± 11.61
Body Fat (kg)	38.01 ± 12.47	41.80 ± 8.98	41.10 ± 15.13
HDL Cholesterol (mg/dL)	52.33 ± 10.85	53.36 ± 15.15	52.77 ± 15.35
LDL Cholesterol (mg/dL)	107.33 ± 30.59	103.50 ± 39.25	115.54 ± 20.19
Total Cholesterol (mg/dL)	176.58 ± 30.15	174.64 ± 42.34	191.38 ± 21.98
Triglycerides (mg/dL)	84.75 ± 20.41	88.29 ± 37.81	115.31 ± 53.51
Glucose (mg/dL)	89.17 ± 8.31+	97.07 ± 7.93+	92.38 ± 6.31
Insulin (uIU/mL)	14.54 ± 8.82	15.23 ± 6.68	16.48 ± 10.45
VO_{2peak} $(mL \cdot kg^{-1} \cdot min^{-1})$	20.34 ± 5.63	20.35 ± 4.82	19.31 ± 5.85
Average Step Count	8750.1 ± 2874.6†	6433.7 ± 2533.0	5340.0 ± 2332.0†
Time in Light Intensity (min)	297.97 ± 58.98+†	231.15 ± 49.39+	210.32 ± 61.92†
Time in Moderate Intensity (min)	15.55 ± 15.56	8.12 ± 14.37	7.00 ± 8.69
Time in Vigorous Intensity (min)	5.16 ± 6.07	3.00 ± 5.13	1.00 ± 1.49
Time in MVPA (min)	20.38 ± 20.33	11.12 ± 18.79	8.00 ± 10.06

+(1-2) Significant difference in time in light-intensity and glucose

†(1-3) Significant difference in Steps and time in light-intensity

Table 5: Tertile Change in Intervention Factors

	Group 1	Group 2	Group 3
Δ Weight (kgs)	-1.44 ± 3.16**	1.12 ± 3.11	1.41 ± 3.35**
Δ BMI (kg/m^2)	-0.49 ± 1.11**	0.46 ± 1.15	0.54 ± 1.25**
Δ Waist Circumference (cm)	-0.81 ± 3.74	1.19 ± 5.25	-1.33 ± 3.47
Δ Body Fat (kg)	-1.37 ± 2.97	0.51 ± 3.12	0.28 ± 2.05
Δ HDL Cholesterol (mg/dL)	-1.25 ± 7.01	-1.14 ± 6.14	-3.00 ± 6.32
Δ LDL Cholesterol (mg/dL)	4.67 ± 15.22	-4.77 ± 15.31	-6.58 ± 16.44
Δ Total Cholesterol (mg/dL)	2.17 ± 21.75	-8.07 ± 17.66	-9.00 ± 21.02
Δ Triglycerides (mg/dL)	-6.42 ± 22.63	-10.14 ± 22.64	-3.77 ± 24.50
Δ Glucose (mg/dL)	-0.67 ± 6.53	-4.57 ±7.80	-0.92 ± 8.87
Δ Insulin (uIU/mL)	-4.14 ± 7.12	-3.26 ± 7.05	-0.82 ± 7.49
Δ VO_{2peak} ($mL \cdot kg^{-1} \cdot min^{-1}$)	2.18 ± 3.65	1.13 ± 2.92	0.03 ± 2.64
Δ Step Count	-1906.0 ± 903.2*	-504.3 ± 363.8*	1026.8 ± 866.3*
Δ Time in Light Intensity (min)	-56.12 ± 34.38†	-25.44 ± 33.10‡	15.79 ± 35.58†‡
Δ Time in Moderate Intensity (min)	-7.43 ± 9.39+†	0.06 ± 6.94+	1.84 ± 4.08†
Δ Time in Vigorous Intensity (min)	-2.00 ± 2.35†	-0.56 ± 3.96	2.17 ± 2.70†
Δ Time in MVPA (min)	-8.92 ± 10.92†	-0.50 ± 9.72	4.04 ± 6.31†

*Significant between group change for all groups in Δ steps ($p \leq 0.05$)

+Significant between group change between Group 1 and Group 2 in Δ time in moderate-intensity ($p \leq 0.05$)

†Significant between group change between Group 1 and Group 3 in Δ time in light-intensity, Δ time in moderate-intensity, Δ time in vigorous-intensity, and Δ time in MVPA ($p \leq 0.05$)

‡Significant between group change between Group 2 and Group 3 in Δ time in light-intensity ($p \leq 0.05$)

**Between group change of weight and BMI between Group 1 and Group 3 approach significant ($p = 0.08, 0.086$)

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APPENDIX: IRB APPROVAL LETTER

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board
4N-64 Brody Medical Sciences Building· Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** ·
rede.ecu.edu/umcirb/

Notification of Continuing Review Approval

From: Biomedical IRB
To: Damon Swift
CC:

Patricia Brophy
Date: 12/12/2019
Re: CR00008209
UMCIRB 14-001737
Effects of Exercise Training Intensity on Fitness and Insulin Sensitivity in African Americans (HI-PACE)

I am pleased to inform you that at the convened meeting on 12/11/2019 12:15 PM of the Biomedical IRB, this research study underwent a continuing review and the committee voted to approve the study. Approval of the study and the consent form(s) is for the period of 12/11/2019 to 12/10/2020.

The Biomedical IRB deemed this study Greater than Minimal Risk.

Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The investigator must adhere to all reporting requirements for this study.

Approved consent documents with the IRB approval date stamped on the document should be used to consent participants (consent documents with the IRB approval date stamp are found under the Documents tab in the study workspace).

The approval includes the following items:

Document	Description
Advertisment(0.04)	Recruitment Documents/Scripts
FFQ(0.01)	Surveys and Questionnaires
HD- HiPAce Flyer(0.01)	Recruitment Documents/Scripts
HiPace consent-CLEAN(0.03)	Consent Forms
HI-PACE flyer(0.04)	Recruitment Documents/Scripts
HiPace Muscle Biopsy Consent(0.01)	Consent Forms
HI-PACE R03-Main Application (FINAL).pdf(0.01)	Study Protocol or Grant Application
Mailer(0.01)	Recruitment Documents/Scripts
MTA agreement(0.01)	Additional Items
Radio Script(0.01)	Recruitment Documents/Scripts
REB for blood samples going to Univ of New Brunswick(0.01)	Additional Items
Short form-36 (Quality of Life Assessment)(0.01)	Surveys and Questionnaires

For research studies where a waiver of HIPAA Authorization has been approved, each of the waiver criteria in 45 CFR 164.512(i)(2)(ii) has been met. Additionally, the elements of PHI to be collected as described in items 1 and 2 of the Application for Waiver of Authorization have been determined to be the minimal necessary for the specified research.

The following UMCIRB members were recused for reasons of potential for Conflict of Interest on this research study:

P. Vos

The following UMCIRB members with a potential Conflict of Interest did not attend this IRB meeting: None