Lewis et al. (2024) *Int J Res Ex Phys*. 19(2):42-56.

Sponsored by:
Exercise and Sport Science Program
Western Colorado University

International Journal of Research in Exercise Physiology

Original Research Article

The Effect of High Intensity Functional Training on Framingham 10-year risk of Heart Attack Score

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ABSTRACT

Introduction: Atherosclerotic Cardiovascular Disease (ASCVD) is the leading cause of death in the US. Individuals who possess three of the five Metabolic Syndrome (MetS) risk factors are two-fold more likely to develop ASCVD. High Intensity Functional Training (HIFT) elicits metabolic benefits as well as being time effective and enjoyable. The Framingham 10-year risk equation is an effective way to measure the probability of an individual encountering a heart attack in the next 10 years. The purpose of this research was to study the effects of different frequencies of HIFT on 10-year risk of heart attack. **Methods:** Twenty-one sedentary individuals with MetS, (males: n=11, females: n=10), were randomly placed into one of three HIFT exercise frequency groups: 1 d·wk^{-1}, 2d·wk^{-1}, or 3d·wk^{-1}. Participants completed individualized HIFT training in a group class setting for 12 weeks. Exercise duration and intensity were progressed over the study. Cardiometabolic components were tested at baseline and post-program (total cholesterol, high density lipoprotein cholesterol [HDL-C], systolic blood pressure [SBP]). **Results:** Although not statistically significant, all HIFT exercise frequency groups reduced their 10-year Framingham risk score for heart attack from baseline to post-program (1 d·wk^{-1}, -0.9%, 2d·wk^{-1}, -0.1%, 3d·wk^{-1}, -0.1%). HDL-C percent change from baseline to post-program was (1d·wk^{-1}: 1.74%, 2d·wk^{-1}: -7.18%, 3d·wk^{-1}: -1.55%), total cholesterol (1d·wk^{-1}: -0.85%, 2d·wk^{-1}: -2.64%, 3d·wk^{-1}: -3.62%), and SBP (1d·wk^{-1}: -2.58%, 2d·wk^{-1}: 0.16%, 3d·wk^{-1}: 2.92%). **Conclusions:** As little as 1d·wk^{-1} of HIFT may elicit similar benefits to heart attack risk reduction as 2d·wk^{-1} and 3d·wk^{-1}.

KEYWORDS: Cardiovascular Disease Risk, Exercise, Metabolic Syndrome.

Introduction

Atherosclerotic Cardiovascular Disease (ASCVD) remains one of the leading causes of death; in the United States (U.S.), it is projected that by 2030 nearly half of adults will develop ASCVD in their lifetime[1]. With

ASCVD predicted to increase over the next 10 years, it is important to look at possible forms of exercise that are effective for ASCVD risk reduction, time efficient, and enjoyable. Individuals with metabolic syndrome (MetS) are 2-fold more likely to develop ASCVD[2]. MetS is the simultaneous occurrence of three or more cardiovascular disease risk factors including 1) visceral/central obesity, 2) hyperglycemia (i.e., high fasting plasma glucose [FBG]), 3) hypertriglyceridemia, 4) low high-density lipoprotein cholesterol (HDL-C), and 5) hypertension (HTN). Presence of these factors elevates the risk of cardiovascular events[3]. Reducing the severity of MetS may therefore serve as a target to improve global health and reduce the incidence of ASCVD. Indeed, increased cardiorespiratory fitness helps protect against the underlying factors constituting MetS[4] and as fitness levels increase, there is a lower risk of cardiovascular mortality in individuals with MetS relative to their less fit counterparts[5]. A previous study[6] explored how community physical activity in individuals with MetS impacts MetS risk factors following a 14-week community exercise class. The study showed that risk factor components were eliminated and cardiorespiratory fitness level increased with personalized exercise. The number of people who identified with MetS was reduced by 10% and there was an 11% increase in the number of people after the program who identified with zero MetS risk factors[6].

Of interest, only 21% of the U.S. population are meeting the current aerobic and muscle-strengthening physical activity guidelines[7] even though there is robust evidence supporting exercise and physical activity to enhance overall health outcomes[8]. Costello and colleagues[9] investigated frequent barriers as to why adults do not exercise or adhere to exercise. The most common barriers were reported as a lack of time, enjoyment, motivation, gym or gym equipment and knowledge. It is imperative to explore exercise modalities that are time effective, enjoyable, and can be done with minimal equipment. Engaging in community high intensity functional training (HIFT) classes could be a viable option to promote physical activity and is in alignment with the objectives of Health People 2030 initiative, an initiative to improve health and well-being over the next decade in the United States[10]. HIFT is defined as a style of training that incorporates functional, multi-joint movements using resistance and performed at high intensity. HIFT has the potential to be more enjoyable and provide greater adherence than other forms of exercise due to exercise variance and novelty of the exercise modality[11] and is a time efficient modality that is reported to promote more intrinsic motivation through social support[7]. HIFT can be modified to any fitness level and over time leads to increased work capacity using a variety of exercises including functional movements with weight, body weight and cardiovascular conditioning. Increased work capacity can be caused due to several body systems working together throughout the workout. HIFT has been shown to be a safe and effective exercise modality with rates of injuries reported as 0.0-3.9 injuries per 1000 hours of training and yields favorable changes in blood work and physiological measures[7]. Overall, HIFT is a practical exercise modality that is time sensitive, especially for individuals reporting time constraints as a primary barrier to exercise participation. In a clinical population, the physiological changes that occur with high intensity functional training are not thoroughly studied. Although, it has been shown that in a clinical population HIFT improves absolute maximal oxygen consumption (VO_2max), insulin resistance, and muscular strength[12]. However, there is a gap in research between HIFT and blood lipids, endothelial function, and other risk factors associated with MetS.

The Framingham 10-year risk calculator is an effective way to measure the probability of an individual having a cardiovascular event in the next 10 years[13]. This calculation takes into consideration age, sex, smoking status, total cholesterol (TC), HDL-C, resting systolic blood pressure (SBP), and whether blood pressure is being regulated with the use of medication. A low-risk score is quantified as less than 10%, moderate-risk score is 10-19%, and high-risk score is over 19%[14].

Individuals with MetS are at greater risk for developing ASCVD and therefore, it is crucial to find exercise options that elicit the most metabolic benefits while being time efficient and enjoyable. HIFT has shown several metabolic benefits and is pleasurable to those who partake in this mode of exercise. Health and cardiovascular risk over the span of 10 years is modifiable through lifestyle alterations and HIFT may a viable method to achieve these goals. Previous research[8] has shown a general dose response relationship between exercise and health outcomes; however, to our knowledge there has been no previous research focused on different frequencies of HIFT and its effect on cardiovascular disease risk. Therefore, the purpose of this study was to investigate the effect of different frequencies of HIFT on 10-year Framingham risk of having a heart attack.

Methods

Participants

Twenty-one physically inactive adults (30-65 years of age; males: n=11, females n=10) who met criteria for MetS volunteered to participate in the study. Participants were included in the study if they met three out of the five risk factors for MetS: visceral adiposity measure by waist circumference (WC) (Men: WC ≥ 102 cm, Females: WC ≥ 88 cm), high triglycerides (TG) (≥ 150 mg/dl), low high-density lipoprotein cholesterol (HDL-C) (≤ 40 mg/dL for men and ≤ 50 mg/dL for women), high fasting blood glucose (FBG) (≥ 100 mg/dL), and hypertension (HTN) (≥ 130/85 mmHg[15]. Participants were excluded from participation if they had any diagnosed cardiovascular, renal, or neurological disease or had functional movement limitations preventing their ability to complete the required exercises. All participants provided written informed consent. This study was approved by the university Human Research Committee at Western Colorado University [HRC2020-01-01-R04].

Experimental design

This study was a secondary analysis of a larger randomized control trial, published elsewhere[16]. A schematic of the secondary analysis is presented in Figure 1. In summary, this study design was used to explore the effect of different frequencies of HIFT on 10-year Framingham risk score. Participants with 3 out of 5 MetS factors were recruited and screened for eligibility for participation. Participants completed baseline testing which included blood work panel and VO_2max via a graded exercise test (GXT). After the completion of baseline testing, all participants attended 2 classes per week for three weeks to learn the movements and exercise techniques to ensure safe participation in the HIFT intervention. After the familiarization period, participants were randomized to one of the three experimental groups. Post-program, all of the same measurements were collected as performed during baseline testing.

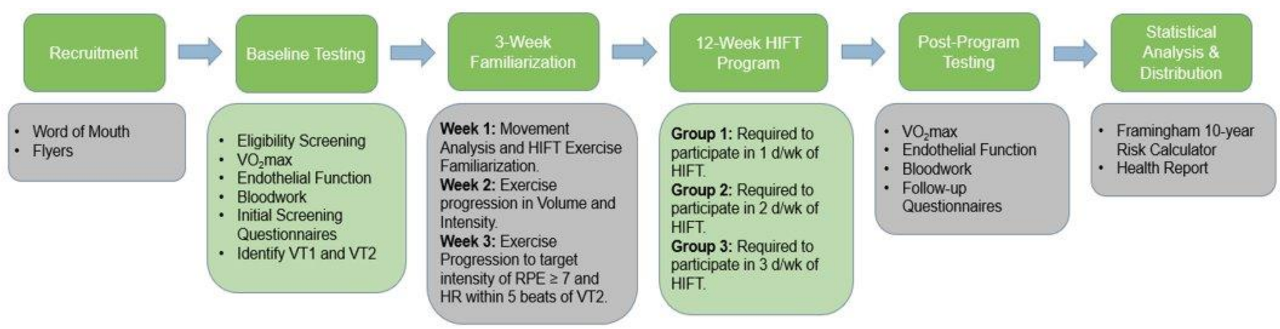

Figure 1. Experimental Flowchart.

Procedures

Baseline and Post-Program Testing Procedures

Measurements of all outcome variables were collected on three separate days and followed standardized protocols. An overview of each measurement is included below. On day 1, participants arrived in a fasted state. Basic anthropometric, seated heart rate, and seated blood pressure measures were obtained as well as blood profile using the Cholestech LDX system (Alere Inc., Waltham, MA). The Cholestech LDX measurements were used as a screening tool for eligibility and data analysis were performed using venous blood sampled (i.e., complete blood analysis). Participants also completed a physical activity and dietary questionnaire and were instructed to maintain their usual diet and activity (outside of the prescribed HIFT protocol) throughout the duration of the study. On day two of testing, participants arrived in a fasted state (12 hr) to complete a more extensive blood panel. Twenty-four to 48 hours after, participants completed a GXT followed by a verification protocol to confirm VO_2max data. All post-program testing protocols were completed two days following the completion of the 12-week intervention and included all of the same measurements and protocols as baseline testing.

Anthropometric Assessments

Participants were weighed to the nearest 0.1 kg on a medical grade scale and measured for height to the nearest 0.5 cm using a stadiometer. Waist circumference measurements were obtained using a cloth tape measure with a spring loaded-handle (Creative Health Products, Ann Arbor, MI). A horizontal measurement was taken at the narrowest point of the torso (below the xiphoid process and above the umbilicus). These measurements were taken until two were within 0.5 mm of each other. Sagittal abdominal diameter was measured following previously published protocols[17].

Seated Heart Rate and Blood Pressure

Standardized protocols for seated heart rate and blood pressure were followed (8). Briefly, participants sat quietly for 5 min with a back support, feet on the floor, and arm supported at heart level. Seated heart rate was obtained via manual palpation of radial artery in the left wrist and recording the number of beats for 60 sec. The left arm brachial artery blood pressure was measured using a sphygmomanometer in duplicate and separated by 1-min. The mean of the two measurements were reported.

Cholestech LDX Blood Lipid Profile

All blood collection and analyses were collected in duplicate and performed at room temperature while strictly adhering to the manufacturer's instructions. Briefly, a small sample of blood (40 uL) from the finger was collected and immediately analyzed to obtain fasting TC, high density lipoprotein cholesterol (HDL-c), low density lipoprotein cholesterol (LDL-c), triglycerides (TRG), and blood glucose using the Cholestech LDX System (Alere Inc., Waltham, MA) test. The mean of the two measurements was reported for baseline and post-program values.

Complete Blood Analysis

Baseline and post-training blood analysis were measured via venipuncture of the antecubital vein. Five milliliters of blood were drawn for the lipoprotein metabolism profile (LMPP), 1 mL for insulin, 1 mL for glucose, 1 mL for HbA1c, and 1 mL for hematocrit. The LMPP consists of an ApoB count, Lp[a] count, and cholesterol and triglyceride content of each lipoprotein subclass (VLDL, LDL, HDL). Hematocrit was calculated to adjust for plasma volume changes applied to the cholesterol and triglyceride content measures. Glucose and insulin measures were used to calculate insulin resistance (IR) using the homeostatic model assessment (HOMA).

Maximal Graded Exercise Test

Baseline and post-training cardiorespiratory fitness were measured via a maximal GXT on a motorized treadmill (CT850, Spirit Fitness, Jonesboro, AR). The GXT began with a 5-min warm-up at a self-selected pace, gradually reaching the pace to be maintained throughout the test. Throughout the test, participants maintained a self-selected speed and incline was increased by 1% each minute until volitional exhaustion. Heart rate was continuously recorded throughout the GXT using a chest strap and radio-telemetric receiver (Polar Electro, Woodbury, NY, USA). Expired air and gas exchange data were recorded continuously during the GXT using a metabolic analyzer (OxyCon Mobile, CareFusion Respiratory Care, Yorba Linda, CA). Before each exercise test, the metabolic analyzer was calibrated in accordance with manufacturer guidelines. Breath-by-breath data were averaged for every 15 sec. The final two consecutive 15 sec data were averaged to represent the data at VO_2max.

Upon completion of the GXT, participants rested passively for 20 min and then completed a verification protocol using previously published methodology[18-19]. Briefly, participants completed a warm up for 5 min at a self-selected speed followed by a volitional test to exhaustion at a constant workload set at 5% higher than the workload of the final completed stage during the GXT. Throughout the verification protocol all of the same measurements were obtained in the same manner as the GXT, including the determination of VO_2max. The VO_2max was confirmed if the VO_2max obtained during the GXT and verification protocol were within ±3.0% of each other. If there was a difference >3.0%, the participant was asked to repeat the GXT and verification protocol with 24-72 h.

Determination of Ventilatory Thresholds

Determination of both the first ventilatory threshold (VT1) and second ventilatory threshold (VT2) were made by visual inspection of graphs of time plotted against each relevant respiratory variable (according to 15 s time-averaging). The criteria for VT1 was an increase in VE/VO_2 without a concurrent increase in VE/VCO_2 and departure from the linearity of VE. The criteria for VT2 was a simultaneous increase in both VE/VO_2 and VE/VCO_2. All assessments were done by two experienced exercise physiologists. In the event of conflicting results, the original assessments were reevaluated and collectively a consensus was agreed upon.

Three-Week Familiarization

In the familiarization period participants attended 2 classes per week, each class was approximately one hour long. During week one the objective was to do a movement analysis on each participant and familiarize the participants with the different HIFT exercises (push, pull, hinge, rotation, step-up, plank, squat, and press). This included different exercises that participants might perform from week-to-week in their workout (e.g., skaters, high knees, butt kicks, jumping jacks, sumo squat, goblet squat, deadlift, TRX bicep curls, push press, plank knee drives, plank frog hops, and seated twist).

Throughout week two, the layout for the HIFT protocol was introduced. This consisted of a warm-up (various range of motion exercises and cardiorespiratory fitness), the HIFT protocol (4 sets followed by a rest period), and a cool down to conclude the class. Overall volume and intensity were increased to half of the phase 1 load (week 1 of the 12-week protocol) while participants continued to learn and familiarize themselves with the movements.

In the final week of the familiarization period, heart rate monitors and rating of perceived exertion (RPE) were introduced. At the end of each set participants were familiarized with collecting their ending HR, set RPE (≥ 7 on the Borg Session RPE CR10 Scale [Borg CR10]), and number of rounds completed for each exercise. Volume and intensity increased to ¾ the load of phase 1.

HIFT Training Intervention

Upon completion of baseline testing, participants were randomly assigned into a frequency dose group consisting of either 1 $d \cdot wk^{-1}$, 2 $d \cdot wk^{-1}$, or 3 $d \cdot wk^{-1}$. Randomization occurred by a 1:1:1 ratio with computer-generated random numbers. Throughout each training session, a HR was continuously monitored. All participants were provided comparable workouts each week based on allocated timing of exercises, work-rest ratio, number of exercises, and maintenance of a BORG CR10 RPE of ≥ 7. There was a standardized warm-up completed that was led by the instructor. Then, workouts would be projected on a screen to allow each participant easier ability to see what exercise they were to perform and the exercises that follow. The workouts all had the same structure of 20 repetitions of a calisthenic type exercise (ex., jumping jacks, skaters, high knees, or butt kicks) at an intensity set at HR ±5 bpm of VT2. This was followed by 6 repetitions of a lower body exercise, 8 repetitions of an upper body exercise, and finally followed by 10 repetitions of a core exercise (abdominal, hip, low-back exercise). Resistance (i.e., weight) were individualized dependent on experience and fitness status with a desired Borg CR10 RPE of ≥ 7. They were asked to repeat the set as many rounds as possible (AMRAP) within the allocated time (see previously published work[16] for timing and progression) and would complete 4 sets with the same format. At the completion of the training session, a cool down was performed with static stretching targeting all the muscle groups that were used during the workout for the day.

Statistical Analyses

Age, sex, TC, HDL-C, smoking status, and SBP were applied to the Framingham 10-year risk score at baseline and post program using the following calculator. All analyses were performed using SPSS Version 25.8 (IBM Corporation, New York, NY USA). For each variable, individual change from baseline were calculated. Data were aggregated as mean ± standard deviation (SD) for each dose group as well as for male and female subgroups with each dose groups. The mean change ± SD for each variable were compared between the 3 dose groups and subgroups. Measures of centrality and spread are presented as mean ± SD. Mean differences in the primary outcome variables between baseline and post program across HIFT frequency groups were assessed with one-way analysis of variance (ANOVA). Where appropriate, Tukey's post hoc tests were performed to determine differences between HIFT frequency groups. The probability of making a Type I error was set at $p < 0.05$ for all statistical analyses. Additionally, to determine the practical assessment of this exercise intervention, magnitude-based inferences were utilized to determine percent benefit, triviality, and harm[20]. A 90% confidence interval was used to express the uncertainty in effect and the clinical meaningfulness (beneficial or detrimental) of this intervention on a metabolic syndrome population. The magnitude-based inference spreadsheet was derived from published literature[20].

Results

Twenty-five participants were recruited for the study. Of these, twenty-one completed post-program testing, four were excluded from the study due to COVID-19 complications (n=1), undergoing cancer treatment (n=1), a pulmonary embolism unrelated to the study (n=1), and personal reason (n=1) that could have substantially confounded the results of the study. The participants that completed the study had 85-100% adherence.

There was no significant ($p > 0.05$) difference in the Framingham 10-year risk between baseline and post-testing; however, there was a favorable response between baseline and post-program within all frequency groups ($1d{\cdot}wk^{-1}$: -0.9%, $2d{\cdot}wk^{-1}$: -0.1%, $3d{\cdot}wk^{-1}$: -0.1%). The greatest reduction in 10-year occurred in the $1d{\cdot}wk^{-1}$ frequency group. The risk factors that encompass the Framingham risk score are HDL-C, TC, and SBP. There was no difference between baseline and post-program in these variables across all frequency groups. Table 1 shows that HDL-C percent change from baseline to post-program was ($1d{\cdot}wk^{-1}$: 1.74%, $2d{\cdot}wk^{-1}$: -7.18%, $3d{\cdot}wk^{-1}$: -1.55%), TC ($1d{\cdot}wk^{-1}$: -0.85%, $2d{\cdot}wk^{-1}$: -2.64%, $3d{\cdot}wk^{-1}$: -3.62%), and SBP ($1d{\cdot}wk^{-1}$: -2.58%, $2d{\cdot}wk^{-1}$: 0.16%, $3d{\cdot}wk^{-1}$: 2.92%).

Clinical Practical Assessment

Magnitude-based inference is an approach to deciding about the true or population value of an effect statistic, considering the uncertainty in the magnitude of the statistic provided by a sample of the population. The inference can be substantially positive or beneficial, trivial, or substantially negative or harmful. As such, these findings are applicable to clinical or practical settings. Table 2 presents that $1d{\cdot}wk^{-1}$ HIFT is possibly beneficial for 10-year reduction; this is supported by that fact that the greatest percent change in 10-year occurred in the $1d{\cdot}wk^{-1}$ frequency group.

Individual Responses

The individual responses for Framingham

10-Year Risk Score of Heart Attack based on each frequency group are presented in Figure 2. In the 1 d·wk^{-1} frequency group 50% (2/4) of individuals reduced their 10-year risk. In the 2 d·wk^{-1} frequency group (4/8) 50% of individuals reduced their 10-year risk. In the 3 d·wk^{-1} frequency group (4/9) 44.4% reduced their 10-year risk.

Table 1. Participant Characteristics, (Mean ± Standard Deviation).

	1 d·wk^{-1} (N=4)		2 d·wk^{-1} (N=8)		3 d·wk^{-1} (N=9)	
	Baseline	Post-Program	Baseline	Post-Program	Baseline	Post-Program
Age (years)	55.3 ± 7.7	55.3 ± 7.7	52.1 ± 12.2	52.1 ± 12.2	56.4 ± 9.4	56.4 ± 9.4
HT (cm)	175 ± 10.3	175 ± 10.3	172.4 ± 6.7	172.4 ± 6.7	170.8 ± 12.7	170.8 ± 12.7
WT (kg)	99.1 ± 18.3	97.2 ± 17.9	87.6 ± 16.0	86.4 ± 15.3	92.9 ± 25.8	93.4 ± 26.0
LDL-C (mg·dL^{-1})	133.8 ± 36.9	126.5 ± 35.6	112.6 ± 42.5	109.9 ± 24.7	140.4 ± 32.3	137.4 ± 28.1
HDL-C (mg·dL^{-1})	46.0 ± 17.5	46.8 ± 11.8	51.5 ± 21.3	47.8 ± 14.4	51.6 ± 20.2	50.8 ± 22.1
TG (mg·dL^{-1})	179.0 ± 167.7	184.0 ± 129.5	172.3 ± 63.3	148.1 ± 44.5	145.0 ± 53.3	133.0 ± 48.5
GLU (mg·dL^{-1})	107.8 ± 22.8	98.3 ± 17.0	100.3 ± 7.0	95.4 ± 8.5	99.8 ± 5.2	98.1 ± 9.6
TC (mg·dL^{-1})	212.3 ± 27.8	210.5 ± 24.3	193.4 ± 58.3	188.3 ± 33.7	220.8 ± 50.0	213.8 ± 40.0
SBP (mmHg)	124.0 ± 11.3	120.8 ± 8.8	128.9 ± 11.4	129.1 ± 15.9	133.4 ± 17.5	137.3 ± 18.5
DPB (mmHg)	80.5 ± 4.7	78.8 ± 5.0	79.3 ± 7.3	78.0 ± 9.4	82.6 ± 6.2	86.8 ± 11.1
WC (cm)	112.5 ± 9.0	108.1 ± 8.2	109.7 ± 17.6	104.3 ± 13.4	112.1 ± 17.1	111.4 ± 17.4
10 YRS (%)	6.4 ± 4.2	5.5 ± 3.3	5.4 ± 5.5	5.3 ± 5.2	7.1 ± 9.2	7.0 ± 8.7

Note: Height (HT). Weight (WT). Low Density Lipoprotein Cholesterol (LDL-C). High Density Lipoprotein Cholesterol (HDL-C). Triglyceride (TG). Glucose (GLU). Systolic Blood Pressure (SBP). Diastolic Blood Pressure (DBP). Waist Circumference (WC). 10-Year Risk Score (10 YRS).

Table 2. Effect of High Intensity Functional Training (HIFT) training on mean changes for 10 Year Risk and variables.

			Chances that the true effect has substantial…			
	Mean Difference	± 90% Confidence Limits	Benefit (%)	Trivial (%)	Harm (%)	Practical Assessment
10 Year Risk + HIFT (relative to baseline)						
Once a week	0.83	0.83, 0.99	48.7	49.9	1.4	Possibly beneficial, +ive
Twice a week	0.18	0.18, 0.32	0.0	99.9	0.0	Most likely trivial, +ive
Thrice a week	0.09	0.089, 0.2	0.0	100.0	0.0	Most likely trivial, +ive
TC +HIFT (relative to baseline)						
Once a week	-1.75	1.8, 4.5	6.9	91.5	1.5	Likely trivial
Twice a week	-5.13	5.1, 9.1	10.7	88.8	0.5	Possibly beneficial, +ive
Thrice a week	-7.0	7, 7.3	23.5	76.4	0.1	Likely trivial
SBP +HIFT (relative to baseline)						
Once a week	-3.25	3.3, 5.7	64.3	30.3	5.4	Unclear, +ive
Twice a week	0.25	-0.25, 0.62	0.0	100.0	0.0	Most likely trivial, +ive
Thrice a week	3.89	-3.9, 6	2.5	42.7	54.7	Possibly, +ive
HDL-C + HIFT (relative to baseline)						
Once a week	0.75	-0.75, 1.9	0.7	97.3	2.1	Very likely trivial, +ive
Twice a week	-3.75	3.8, 6.9	44.6	52.1	3.2	Possibly beneficial, +ive
Thrice a week	-0.78	0.78, 1.5	0.2	99.8	0.0	Most likely trivial, +ive

If chances of benefit and harm both > 5% the true effect was deemed unclear (could be beneficial or harmful). Otherwise, chances of benefit or harm were assessed in the following manner: <1%, almost certainly not, 1-5%, very unlikely; 5-25%, unlikely; 25-75%, possibly; 75-95%, likely; 95-99%, very likely; >99%, almost certain.

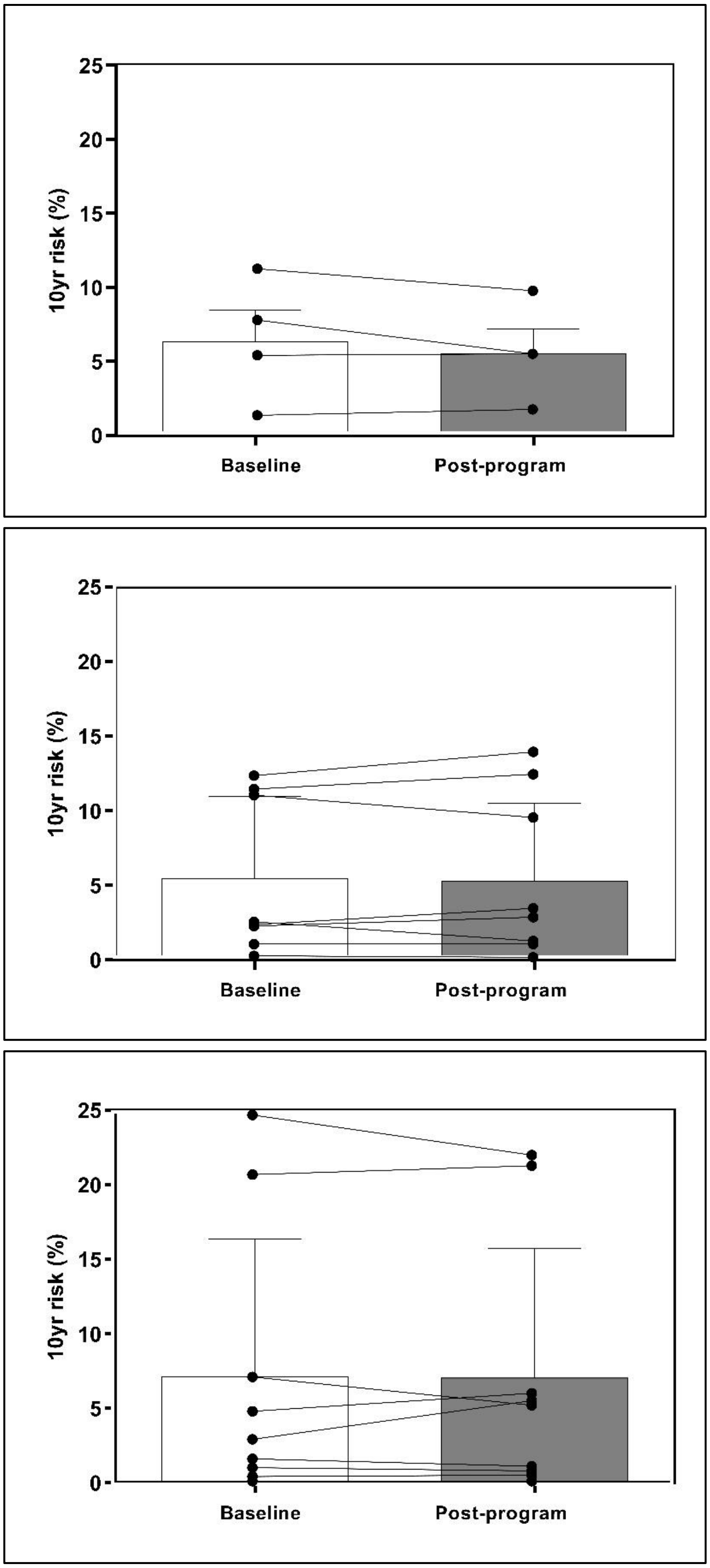

Figure 2. Individual Framingham 10-Year Risk Score of Heart Attack at baseline and post-program for each frequency group: 1 d·wk^{-1} (upper panel), 2 d·wk^{-1} frequency group (middle panel), and 3 d·wk^{-1} frequency group (lower panel).

Discussion

To our knowledge, this was the first study to evaluate different frequencies of HIFT on changes in the 10-year Framingham risk score. Our primary finding was that there was not a significant difference between 1, 2, and 3 d·wk^{-1} of HIFT training and reductions in 10-year heart attack risk score in a MetS population. However, based on the clinical meaningfulness determined with magnitude-based inferences, 1 d·wk^{-1} was possibly beneficial whereas 2 and 3 d·wk^{-1} were deemed likely trivial. These findings are encouraging and provide important preliminary insight into the optimal frequency of HIFT for reducing the burden of heart disease.

Previously, Dalleck and colleagues[6] examined a 14-week supervised community-based intervention (average intensity of 42% VO_2 reserve) aimed at lowering cardiometabolic risk factors, including key measurements that encompassed the Framingham 10-year risk score. Indeed, they found significant decreases in 10-year risk scores for both men and women with baseline to post program changes of 9.9±6.2 to 9.1±5.6 percent and 1.5±2.2 to 1.3±1.7 percent, respectively. These findings are comparable to the present study. Differences in statistical outcomes are likely due to our sample starting at a lower 10-year risk score and therefore, having less room for improvements. It should be noted that percent improvements in 10-year risk were comparable even with differences in relative exercise intensities with an average improvement of 0.8% and 0.2% for men and women reported previously[6] and average improvements of 0.9%, 0.1%, and 0.1% for 1, 2, and 3 d·wk^{-1}, respectively, in the current study.

In a subsequent investigation into the same large community exercise program[21], participants were separated into specific metabolic- based groups of metabolically healthy but obese (MHO; individuals with BMI ≥ 30 kg/m^2 and had one or zero MetS risk factors) and metabolically abnormal obese (MAO; individuals presented with BMI ≥30 kg/m^2 and or had two or more MetS risk factors). A significant number of participants transitioned from MAO at baseline to MHO post program. However, the 10-year risk score change positively by an average 0.4%, which was comparable to the results of our investigation. Their findings suggest with higher volumes of exercise, there will be an increased potential for an individual to transition from MAO to MHO, but may not significantly improve 10-year risk scores. It is noteworthy that both moderate continuously aerobic exercise and HIFT for 1, 2, and 3 d·wk^{-1} yield comparable improvements in the Framingham 10-year risk scores.

A study done by Ramos et al.[22], investigated different volumes of high intensity interval training (HIIT) and found that low volume HIIT (i.e., HIIT 1x4min at 85-95% HR peak) was as effective as high volume of HIIT (i.e., HIIT 4x4min at 85-95% HR peak) and moderate intensity continuous training (30 min at 60-70% HR peak) in improving MetS severity. The reduction in MetS z-score severity in low volume HIIT compared to high volume HIIT was 3-fold greater. These findings support the present study where lower frequency HIFT was as effective as higher frequency HIFT. Specifically, looking at the results in SBP, Ramos et al.[22] found that low volume HIIT had a decrease whereas the high volume HIIT had an increase in SBP which followed the trends in improvements of SBP in the current study with lower volume HIFT having a positive improvement and high frequency moving in an unfavorable direction (SBP changes of 1d·wk^{-1}: -2.58% vs. 3d·wk^{-1}: 2.92%).

In the Framingham 10-year risk of heart attack calculation, the variables included and potentially impacted by the HIFT intervention include SBP, HDL-C, and TC. Looking at the mean difference between baseline and post-program, as shown in Table 1, it should be noted that that SBP in 1 d·wk^{-1} decreased while 2 and 3 d·wk^{-1} increased from baseline to post-program. There are a few potential factors underpinning these findings, including the demographics of the population studied and oxidative stress.

When healthy men were separated into 3 groups (mild, moderate, and high intensity) of cycling 5-7 weeks for 12 weeks, it was found that 12 weeks at moderate and not mild or high intensity augmented endothelium dependent vasodilation through increases in nitric oxide production[23]. The increase in exercise intensity was accompanied by a subsequent increase in plasma concentration of markers indicative of oxidative stress; therefore, it was concluded that long term high intensity activity may impair endothelium dependent vasodilation through a decrease in antioxidants and increase in reactive oxygen species resulting in nitric oxide bioavailability. These findings would suggest that higher volume of extreme amounts of high intensity exercise blunts nitric oxide production and thereby increasing SBP. While this was not directly studied, the blunting of nitric oxide production could be a possible mechanism underpinning the findings of the present study. However, these findings are paradoxical given a recent meta-analysis found that high intensity interval training, dynamic resistance training, combined aerobic and resistance training, as well as aerobic training were effective in reducing both systolic and diastolic blood pressure at rest[24].

From a clinical standpoint, individuals with MetS are at greater risk for heart attack and therefore, have a higher Framingham risk score. As little as 1d·wk^{-1} of HIFT may be effective at attenuating the risk of future heart attack. For those who struggle with a finding adequate time to participate in the recommended amount of physical activity/exercise a week[9] could implement the HIFT protocol as a viable time sensitive option to improve overall health outcomes. In all frequency groups HIFT exhibits health maintenance and benefits in 12 weeks of training. However, the greatest enhancement in 10-year risk was in the 1 $d \cdot wk^{-1}$ group; 2 and 3 $d \cdot wk^{-1}$ groups had a slight, non-significant, reduction in their 10-year risk score for heart attack. This shows that in just 12 weeks of HIFT training an adult with MetS can reduce their risk of having a heart attack in the next ten years. Furthermore, previous HIFT research shows improvements in metabolic and health markers specifically in body composition, muscular strength and power, and aerobic capacity along with being enjoyable in a healthy population[7]. The present study extends previous findings to a clinical population. We found improvements in TC, LDL-C, TG, WC along with Framingham 10-year score across all frequency groups. Another important observation from the present study is how well-tolerated the HIFT intervention was for individual with MetS, which is likely attributable to its personalized nature and enjoyable aspect.

Limitations

We recognize the current study is not without limitations. While the HIFT protocol and design was intended to be a real-world setting to enhance ecological validity, the setting led to considerable limitations and reductions in the overall sample size due to occurring within the COVID-19 pandemic. Throughout the study, there were several surges of infections, changes in masking requirements, and group size regulations that significantly impacted our ability to maintain a high sample size and, ultimately, these factors contributed to the study being underpowered.

Conclusions

In conclusion, HIFT led to a possibly beneficial decrease in 10-year Framingham risk score of heart attacks in individuals with MetS. As little as $1d \cdot wk^{-1}$ of HIFT may elicit similar benefits to heart attack risk reduction as $2d \cdot wk^{-1}$ and $3d \cdot wk^{-1}$. Our findings are aligned with previous results suggesting lower frequency of exercise can still elicit positive health adaptations in participants with MetS. With time and adherence as a commonly reported barrier for exercise participation, our findings that approximately 1 hour of $HIFT \cdot wk^{-1}$ can improve health outcomes in individuals currently experiencing MetS is extremely encouraging.

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