# HIGH INTENSITY INTERVAL TRAINING (HIIT) VS. TRADITIONAL CONTINUOUS TRAINING (CT): TESTING THE CARDIOVASCULAR BENEFITS ACROSS A WIDE AGE SPECTRUM- A PILOT STUDY

By

Neil Grobler and Brandy Parker

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## - ABSTRACT -

High intensity interval training (HIIT) has evolved into a popular method of cardiovascular training over recent years, however its benefits have only been explored in specific populations. It has rarely been studied in comparison to continuous training (CT). Thirteen healthy participants (21-44 years; 5 males, 8 females) were assigned to 1 of 2 groups based on baseline $VO_{2max}$, gender, and age. Six participants (4 female, 2 male; $VO_{2max}$ average 37.370 ± 3.812 ml/kg/min) executed a HIIT regimen lasting 5 weeks, while the remaining seven individuals (4 female, 3 male; $VO_{2max}$ avg 39.896 ± 5.161 ml/ kg/min) participated in a CT regimen of equal duration. Subjects assigned to the CT group realized a significant change in exercise test time from initial to final testing, which resulted in an overall significant change in $VO_{2max}$ values. Subjects who were assigned to the HIIT group did prove an overall change, however, the level of change was not statistically significant. Although the CT group experienced significant change from initial to final testing (within group), the between group analysis did not yield significant results, perhaps due to small sample size. All individuals experienced an increase in overall exercise time and $VO_{2max}$ values from initial to final testing, regardless of exercise group assignment. Although no significant difference was apparent when analyzing exercise time and subsequently $VO_{2max}$ values between the two experimental groups, the statistical significance experienced independently within the CT group warrants further investigation with a larger sample size to yield more conclusive results. In this regard, when compared, neither HIIT nor CT truly proved to be a more beneficial or effective form of training, potentially allowing HIIT to be a viable substitute for CT in terms of cardiovascular exercise.

PILOT STUDY

**NEIL GROBLER**, SPT, CSCS • **BRANDY PARKER**, SPT, CSCS
**SHELLY WEISE**, PT, EdD

# High Intensity Interval Training (HIIT) vs. Traditional Continuous Training (CT): Testing the Cardiovascular Benefits Across a Wide Age Spectrum - A pilot study

*-Angelo State University Doctor of Physical Therapy Program-*


- STUDY DESIGN: Matched Pairs Design
- OBJECTIVE: To compare the health benefits of participation in traditional continuous cardiovascular exercise (CT) versus high intensity interval training (HIIT) across a wide age spectrum
- BACKGROUND: HIIT has evolved into a popular method of cardiovascular training over recent years, however its benefits have only been truly explored in specific populations, and furthermore rarely in comparison to traditional CT.
- METHODS: Thirteen healthy participants (21-44 years; 5 males, 8 females) were assigned to 1 of 2 groups based on: baseline $VO_{2max}$, gender, age. Six participants (4 female, 2 male; $VO_{2max}$ avg 37.370 ± 3.812 ml/kg/min) executed a HIIT regimen lasting 5 weeks, while the remaining seven individuals (4 female, 3 male; $VO_{2max}$ avg 39.896 ± 5.161 ml/ kg/min) participated in a CT regimen of equal duration.
- RESULTS: Subjects assigned to the CT group realized a significant change in overall exercise test time from initial to final testing, which resulted in an overall significant change in $VO_{2max}$ values. Subjects who were assigned to the HIIT group did realize an overall change; however the level of change was not statistically significant. Although the CT group experienced this significant within group change from initial to final testing, the between group analysis did not yield significant results, perhaps due to small sample size.
- CONCLUSION: All individuals experienced an increase in overall exercise time and $VO_{2max}$ values from initial to final testing, regardless of exercise group assignment. When compared, neither HIIT nor CT proved to be a more beneficial or effective form of training. Potentially, this allowing HIIT to be a viable substitute for CT in regards to cardiovascular exercise.
- KEY WORDS: *Interval training; Continuous training; $VO_{2max}$*


## - INTRODUCTION -

With the development of a new healthcare system, a subsequent push for greater emphasis on preventative health care is coming to fruition. This is evident not by premium penalties based on health status, something the Affordable Care Act (ACA) was put in place to combat, but rather by premium incentives based on items such as smoking and obesity, derived from an individual's body mass index (BMI). It can be deduced by mere logic that due to the expansion of healthcare to a greater number of individuals the health care sector is looking for ways to encourage the public to stay healthy in anticipation of a depletion of current resources.

Improved access to health care also means more educated consumers. As a result of the ACA, a far greater percentage of the population will have access to education via their health care team in regards to general conditioning leading to a healthier lifestyle. Physical therapists are trained to see each person as a whole and not its individual parts, for which care often involves cardiovascular exercise prescription. Although physical therapists are well educated on the benefit of cardiovascular exercise, they also realize the constraints of time in an average American work week and are aware that exercise sits on the back burner for many individuals. This in itself gave enough reason to create a pilot study aimed to investigate the most time-efficient way in which to participate in cardiovascular exercise.

It has been shown that $VO_{2max}$ values have been accepted as the basis for determining cardiovascular fitness.[1] Simply put, $VO_2$ is a measure of the oxygen transport system's ability to deliver blood and the ability of cells to utilize the oxygen for energy production. [1] These $VO_2$ values can be obtained by participation in a maximal exercise test (i.e. Bruce Protocol Treadmill Test), or by deriving a predicted maximum oxygen consumption ($VO_{2max}$) from submaximal exercise test results.

HIIT has become a popular trend or fad over recent years. HIIT describes physical exercise that is characterized by brief, intermittent bursts of vigorous activity, interspersed by periods of rest or low-intensity exercise.[2] In terms of intensity HIIT is typically described as exercising at 85% of an individual's $VO_{2reserve}$ (or $HR_{reserve}$).[3] In contrast, CT for the average, healthy adult can be defined as 30-60 minutes of exercise at 40-65% of an individual's $VO_{2reserve}$ (or $HR_{reserve}$), and should be performed 3-5 times per week.[3] There is a cardiovascular health benefit gained with participation in either a HIIT or CT regimen, however the extent of the benefits gained across a diverse population in regards to age still warrants further research.

Current existing literature seems to focus on exploring the benefits of HIIT in comparison to CT within specific populations based on age, gender, or overall health status. For example, HIIT is often associated with more vigorous and harsh specific exercises which some deem unreasonable and unsafe. Therefore, most studies have used healthy, college-aged individuals as subjects.[2, 4, 5-9] On the contrary, some studies have only focused on a diseased population, commonly looking into heart disease and diabetes.[2, 10-13] Thus, the gains realized with HIIT in the aforementioned studies can only be applied to the populations previously mentioned. This leads to an overwhelming gap in research when attempting to apply the results from existing research to the general, healthy adult population which is much more diverse in regards to both age and physical level of fitness. Therefore, the purpose of this study was to investigate if HIIT could serve as a reasonable alternative to traditional, continuous means of cardiovascular exercise across a vast age range. Based on existing research the investigators hypothesized that cardiovascular health based gains realized after participation in a HIIT regimen would closely mirror the gains realized after participation in a CT regimen, regardless of age.

## - **METHODS** –

### Study Design

This matched pairs design study compared objective measures of improvement in cardiovascular health between two wide-range aged groups of subjects participating in different exercise regimens: a HIIT group, and a CT group. An attempt to formulate homogeneous groups based on initial $VO_{2max}$, gender, and age was made. The primary variables investigated in this study were: $VO_{2max}$ and exercise time. Other parameters of interest were: resting blood pressure ($BP_{rest}$), resting heart rate ($HR_{rest}$), and body composition – total fat percentage as measured by bioelectrical impedance analysis (BIA). The study design, protocol, and informed consent were

presented to the Angelo State University Institutional Review Board (IRB), which granted permission for further investigation while ensuring protection of all subjects involved.

## Subjects

Recruiting for this study was open to all healthy individuals age 18-50 years in the city of San Angelo, Texas. For this study "healthy" was defined utilizing the American College of Sports Medicine's (ACSM) risk stratification system. All subjects participating in this study were classified as "Low Risk" in regards to participation in both submaximal and maximal exercise testing.[3] This "Low Risk" assignment was derived from denial of a list of questions regarding risk factor thresholds for cardiovascular disease (see Appendix 1).[3] Further pre-participation screening was administered via the Par-Q & You as well as the AHA/ACSM Health & Fitness Facility Pre-participation Screening Questionnaire (see Appendix 2 & 3). Individuals were not allowed to participate in the study if they indicated having been previously diagnosed with a cardiovascular, pulmonary, and/or metabolic disease.

A total of 14 subjects were initially successfully recruited, screened for participation, and tested for all baseline values; however only 13 subjects' (n = 13; age = 29.615 ± 7.578; 8 females & 5 males) data was analyzed for results due to early attrition of 1 participant. All subjects signed a written informed consent before onset of participation in the study and also offered a personal verbal time commitment of 5 weeks for successful participation in the study.

## Procedures

All 13 subjects completed two rounds of formal testing, including two Bruce Protocol Treadmill Tests, to obtain baseline and final $VO_{2max}$ values. Both of these tests were performed on the campus of Angelo State University. During initial baseline testing subjects were not yet assigned to an exercise protocol group. An experimental file was created for each individual

subject, and the following data was recorded: Gender, age, calculated $HR_{max}$[3], number of risk factors from pre-participation screening (< 2 for all subjects), height, weight, BMI, fat percentage from BIA, glucose level, $HR_{rest}$, $BP_{rest}$, and $O_2$ saturation at rest.

Subjects were then debriefed on the parameters of the Bruce Protocol Treadmill Test including safety features and how to stop the test when desired (Table 1).[14] In addition to subjective request for stoppage due to max exercise or fatigue, the initial baseline testing would have also been stopped if the subject experienced: angina, drop in systolic blood pressure (SBP) > 10 mmHg from baseline despite increased workload, excessive rise in BP: SBP > 250 mmHg or diastolic blood pressure (DBP) > 115 mmHg, shortness of breath, claudication/leg cramps, light-headedness, confusion, nausea, cyanosis, pallor, ataxia, failure of heart rate to increase with increased workload, heart palpitations, physical or verbal manifestations of severe fatigue.

All subjects were equipped with a 12-lead electrocardiogram (ECG) for initial $VO_{2max}$ testing to grossly assess for any obvious adverse cardiovascular reactions to the maximal exercise test. Blood pressure of each subject was also taken during the first 3 stages of the Bruce Protocol Treadmill Test to ensure an appropriate response to exercise. The gas analyzer and software was calibrated prior to initial and final $VO_{2max}$ testing. During the Bruce Protocol Treadmill Test gas exchange was continuously monitored by breath-by-breath analysis at initial testing and via a digital flowmeter system and sample line at final testing, reasoning for different equipment will be later explained. During initial $VO_{2max}$ testing subjects donned a hard, head-gear set including a 3-way valve which was placed inside the subject's mouth, and a nose-clip to block gas exchange through the nose. During final $VO_{2max}$ testing subjects wore a soft plastic mouth and nose piece that was not inserted into the mouth but rather simply covered the mouth and nose. Throughout the maximal exercise test, all subjects were asked to communicate their

respected rate of perceived exertion (RPE) during each stage via hand signals. After the subject alerted the investigators to stop the test, the investigators aborted the protocol but maintained a speed of 2.0 mph and 0% grade incline, allowing for effective recovery while investigators monitored recovery blood pressure and heart rate.

After the initial $VO_{2max}$ testing was complete, individuals were randomly assigned numbers in order to establish groups according to the following information: initial $VO_{2max}$, gender, and age. Although the sample size was significantly small, an attempt was made to construct two homogenous groups based on the aforementioned parameters, which resulted in six subjects placed in the HIIT group and seven in the CT group. Upon assignment of individuals to the two separate exercise groups, subjects were notified of their respective 5-week exercise protocol (Appendix 4).

The exercise protocols were constructed based on information derived from the literature review and the data gathered within.[3, 15-16] Subjects were expected to complete their respected exercise protocol 3 times per week for the duration of 5 weeks, totaling 15 workouts, with instructions to avoid performing back-to-back days of their exercise protocol. Participants were educated to use the study's exercise protocol in conjunction with the exercise and activities already being performed on a daily basis prior to their enrollment in the study. All subjects' first exercise session was performed at the Center for Human Performance on the campus of Angelo State University under the supervision of both student investigators to ensure the correct execution of their exercise protocol. Prior to initiation of their 5 week exercise regimen, all subjects were issued a pre-programmed Polar™ heart monitor strap and watch which was to be worn during all workouts in order to maintain correct exercise intensity throughout each training session. All other exercise sessions over the 5 weeks were performed on the subjects' own time,

3 times per week, with the use of a treadmill. Subjects were asked to keep a written or electronic record of all exercise sessions in order to promote participation and discourage attrition.

Polar™ HR monitors contained a personalized programmed HR range based on training intensities derived utilizing percentages of individuals' $HR_{reserve}$ values. $HR_{reserve}$ is directly related to $VO_{2reserve}$ and thus can be used interchangeably when prescribing exercise.[3] Subjects' $HR_{max}$ was determined using the formula: $HR_{max} = 206.9 – (.067 \times age)$. This was then utilized to determine a desired target HR (THR) zone via the Karvonen formula. As previously described, participants in the HIIT group worked at 80-90% $HR_{reserve}$, and the CT group worked at 55-65% $HR_{reserve}$. Upon completion of the final, 15th, workout session, a second $VO_{2max}$ test via the Bruce Protocol Treadmill Test was performed. The same health parameters that were assessed at baseline were re-assessed at this time. All subjects were also asked to submit their written or electronic record of participation in the study, outlining all 15 exercise sessions. Subjective level of compliance was offered upon final testing, 100% representing complete maintenance of pre-participation level of activity with the study's exercise regimen used only in addition to regular daily routines. Lastly, subjects were prompted for an overall subjective level of satisfaction on a 1-5 scale, where 1 indicated complete dissatisfaction and 5 indicated complete satisfaction.

Prior to final $VO_{2max}$ testing, investigators experienced an equipment malfunction that could not be resolved. A different gas exchange analysis system and metabolic cart was therefore used for final testing (Table 2). To ensure the integrity of results the Foster Equation (Figure 1) was used to convert exercise time to predicted $VO_{2max}$ values.[17] The Foster Equation is a regression equation developed via the use of 230 male subjects with various ages.[17] Although derived exclusively using male subjects, this equation has been successfully applied across a

| *Figure 1 - Foster Equation* |
| --- |
| Foster Equation: $VO_{2max} = 14.76 – 1.379 \times (time) + .451 \times (time)^2 - .012 (time)^3$ |

wide age spectrum and across genders to convert exercise time on the Bruce Protocol Treadmill Test (in minutes) to $VO_{2max}$ values.[18]

### Statistical Analysis

All data was analyzed using IBM SPSS Statistics Version 21. The main parameters of interest were total exercise time and $VO_{2max}$, with secondary parameters of interest being $HR_{rest}$, $BP_{rest}$, BIA – total fat percentage. Statistical significance for all data analysis was set at .05. Normality of CT and HIIT population distribution was first assessed independently utilizing the Kolmogorov-Smirnov and Shapiro-Wilk tests. A Mann-Whitney U Test was then executed in order to compare groups in regards to the primary and secondary parameters of interest at the time of initial testing. Wilcoxon Signed-Rank Tests were then executed to examine differences in the initial and final values within the HIIT group and the CT group independently. Finally, an additional Mann-Whitney U Test was used to compare the difference in the final values of the parameters of interest between the exercise groups.

## - **RESULTS** -

Percent change from initial to final testing in regards to $VO_{2max}$ was analyzed within each age specific category compromising the HIIT and CT groups (Table 3). The greatest percent change realized from initial to final $VO_{2max}$ values occurred in the HIIT group for subjects ages 24-29 years old and in the CT group for subjects age 18-23 years old. Percent change from initial to final testing in regards to $VO_{2max}$ was also analyzed as it related to subjective reported study compliance, which was higher in the CT group. Based on all individuals who subjectively reported greater than 75% study compliance, subjects within the CT group realized a greater increase in exercise time translating to a greater increase in $VO_{2max}$ (Table 4). It should be noted,

however, that although compliance was lower for the HIIT group, average reported subjective level of satisfaction was higher.

Descriptive statistics for the entire subject population demonstrated a wide age range: 21-44 years old, with more female than male subjects – 8:5, respectively. The average $VO_{2max}$ value during initial testing was calculated to be 38.73 ml/kg/min, whereas the average $VO_{2max}$ value after final testing was calculated to be 42.357 ml/kg/min (Table 5). Further analysis of this data showed a change in average $VO_{2max}$ values from 39.896 (±5.161) ml/kg/min at initial testing to 44.92 (±4.271) ml/kg/min upon final testing for the CT group; and a change in average $VO_{2max}$ values from 37.3700 (±3.812) ml/kg/min at initial testing to 39.367 (±8.938) ml/kg/min upon final testing for the HIT group. Overall, 12 of the 13 total subjects realized an increase in exercise time and increase in derived $VO_{2max}$ from initial to final testing (Figure 2).

Upon examination of both the CT group's and HIIT group's initial population distribution, it became evident that the HIIT group's population was abnormally distributed in regards to initial $VO_{2max}$ values. The Kolmogorov-Smirnov and Shapiro-Wilk tests both provided statistically significant values. However, both groups proved to have normal distribution of the population in regards to age. Due to the study's unproportioned distribution of female: male subjects, both groups' population was abnormally distributed in regards to gender. Due to the lack of normal population distribution, non-parametric tests were utilized for statistical analysis.

A Mann-Whitney U Test executed after initial testing, but prior to initiation of the 5 week exercise period, demonstrated no statistically significant difference in the CT group and the HIIT group when compared in regards to all parameters of interest (Table 6).

A Wilcoxon Signed-Rank Test used to analyze the difference in parameter values from initial to final testing within the HIIT group demonstrated no significant change for any

parameter of interest (Table 7). However, upon further analysis, a myriad of different results could be deduced. Of the 6 total participants in the HIIT group: only 1 individual experienced a decrease in $HR_{resting}$ from initial to final testing, 3 individuals experienced a decrease in both $SBP_{resting}$ and $DBP_{resting}$ from initial to final testing, 4 individuals experienced a decrease in total fat percentage as measured via BIA from initial to final testing, and perhaps most importantly 5 individuals realized an increase in both exercise time and $VO_{2max}$ from initial to final testing.

A Wilcoxon Signed-Rank Test used to analyze the difference in parameter values from initial to final testing within the CT group demonstrated a statistically significant change for exercise time and $VO_{2max}$ (Table 8). Additionally, of the 7 total participants in the CT group: only 4 individuals experienced a decrease in $HR_{resting}$ from initial to final testing, 3 individuals experienced a decrease in $SBP_{resting}$ and 2 individuals experienced a decrease in $DBP_{resting}$ from initial to final testing, 5 individuals experienced a decrease in total fat percentage as measured via BIA from initial to final testing, and all 7 individuals realized an increase in both exercise time and $VO_{2max}$ from initial to final testing.

A Mann-Whitney U Test executed at the conclusion of the study, comparing the final parameters of interest between the HIIT group and CT group demonstrated no statistically significant difference in any of the parameters in interest (Table 9).

**- <u>DISCUSSION</u> –**

The purpose of this study was to examine whether HIIT would be an effective mode of exercise across a wide age spectrum in comparison to CT. Research has explored interval training as an appropriate substitute for continuous forms of cardiovascular exercise, but a majority of these studies were conducted using a young, healthy population (college athletes), or the diseased population (status post cardiovascular procedure or diagnosed heart failure).[2, 4, 5-13]

Since it is known that HIIT can yield the same, if not better, results compared to CT in the specific populations listed above, research was warranted to see if the effects of HIIT matched the effects of CT over a wider age range more representative of the general population. The investigators anticipated that HIIT and CT groups would obtain similar results at the conclusion of this study, resulting in evidence to support the idea of shortened, more intense workouts which would encourage participation in exercise due to a smaller time commitment. In the field of physical therapy, this study could potentially lend evidence to suggest HIIT as a viable substitute for CT, pending an otherwise healthy subject.

Initially the study was constructed to analyze the differences in the two exercise groups based on four age-based categories. However, due to the small sample size of this study the investigators believed that more meaningful results would be available if statistical analysis were performed on the entire HIIT group versus the entire CT group, keeping age a secondary variable in which to report overall trends such as percent change previously mentioned (Table 3).

Although normality of population distribution was not achieved in regards to certain parameters, there was no statistically significant difference between the 2 exercise groups at initial testing. This allowed for more meaningful comparison of data at the time of final testing, as the two exercise groups did not significantly differ in regards to all parameters of interest before initiation of their respected interventions.

The main primary parameters of interest of this study were total exercise time and $VO_{2max}$, with secondary parameters of interest being: $HR_{rest}$, $SBP_{rest}$, $DBP_{rest}$, and BIA – total fat percentage. $VO_{2max}$ values derived from total exercise time provided means of assessing cardiovascular health improvements, perhaps in the most direct and accurate fashion.[17] HR and BP (both SBP and DBP) were direct physiological measurements of cardiovascular health and

thus provided direct insight into cardiovascular status. Body composition was a secondary parameter of concern due to its ability to directly show the benefits of exercise. There have been countless studies on the overall effect of poor body composition, high fat percentage, and the negative effects these parameters have on cardiovascular health. Although BMI has evolved into a measurement easily used in the clinic, BIA has been proven to gather the same information as the BMI calculation, thus providing a reference to compare body composition.[19]

The results from this study illustrated that individuals who participated in a 5 week CT program realized a significant change in overall exercise time from initial to final testing, which resulted in an overall significant change in $VO_{2max}$. Subjects who were assigned to the HIIT group also realized an overall positive change; however, the degree of change was not statistically significant. Although the CT group experienced a within-group statistically significant change from initial to final testing in regards to exercise time and $VO_{2max}$, there was no statistical difference between the two exercise groups at final testing for any of the primary or secondary parameters of concern (Table 9). This potentially provides an argument supporting HIIT as a substitute for CT in regards to cardiovascular exercise. It should be noted, however, that the presence of large standard deviations in regards to the primary parameters of exercise time and $VO_{2max}$ raise cause for concern when comparing between two independent populations (HIIT group vs. CT group). However, based on the results from the study, it cannot be deduced that either HIIT or CT is more beneficial or effective in positively altering the primary or secondary parameters of concern. This study was created as a pilot study in order to call attention to the lack of research available to the applicability of HIIT as a substitute for CT toward the general, healthy population, and therefore the results did not make this study unsuccessful. A meta-analysis by Ramos et. al. reviewed 7 randomized clinical trials coming to the conclusion

that HIIT is a more beneficial form of exercise than CT when examining cardiorespiratory fitness, insulin sensitivity, and cardiovascular risk factors. (Ramos) Another randomized clinical trial looked at the effects of combine CT and HIIT (4 CT sessions and 1 HIIT session) to CT only and a sedentary control group. They found that there were $VO_{2max}$ gains in both of the CT+HIIT and CT only groups, and a decrease in $VO_{2max}$ in the control group. Although the CT+HIIT group obtained higher gains than the CT only group, the increase was not significant. This current experiment is similar to this study, because both intervention groups demonstrated $VO_{2max}$ gains, neither one proved to be significant. (Roxburgh) The CT+HIIT study may have seen significant results had they structured the protocol for a greater number of HIIT sessions per week (i.e. 3 CT sessions and 2 HIIT sessions).

## Limitations

Due to the experimental nature of the study, several factors could have impacted the ability to generalize the results to a larger population. Again, the small sample size in each exercise group did not allow for generalizability or assumptions, and although the sample size covered a wide age range, there were still more individuals aged 18-29 who participated which may have skewed results. Had analysis been conducted with the study's initial intentions with emphasis on age, it would have been nearly a one-to-one case study comparison for particular age categories, making comparison across age groups nearly impossible.

Participant mindset may have also played a role in results. About half of the subjects had participated in some type of $VO_{2max}$ testing or graded exercise test at an earlier date. These subjects were also aware of what to expect regarding exercise tolerance and fatigue level. Depending on the time of day and the time of their last meal, this may have had a positive or negative effect on subjects' results. Investigators gave instructions to fast for 2 hours prior to the

max test for an accurate blood glucose reading and for the comfort of the patient during the max test. Adherence to the study was an additional limiting factor, as the subjective levels of compliance ranged anywhere from 5-100%, with the average percentage of compliance for the CT group being 74.286% and 70.833% for the HIIT group. The higher level of compliance reported by subjects of the CT group could also potentially provide more reason as to why this group demonstrated a significant change from initial to final testing in regards to total exercise time and $VO_{2max}$. The diligence of the participants was monitored only via review of written exercise logs, which were turned in at the end of the data collection period, and via weekly e-mail reminders to encourage adequate and consistent participation from all subjects.

All baseline $VO_{2max}$ tests were conducted with accompanying 12-lead ECG and full $VO_{2max}$ head gear. During calibration of gas analyzers prior to final max tests, the $O_2$ analyzer ceased to give accurate readings which led to the use of a different treadmill and metabolic cart for final tests. No simultaneous ECG was taken during the second round of tests, and a different, more comfortable face mask for gas exchange measurements was used which could have influenced exercise times. Also due to the change in equipment, $VO_{2max}$ results used for analysis were calculated according to total treadmill time using the Foster equation to maintain consistency when analyzing data across the study.

Controlling subjects' level of activity outside of the study was an issue of great concern to the investigators. As previously mentioned, attempts were made to control this variable, however normal distribution between the two groups based on initial $VO_{2max}$ values was not adequately obtained. Lastly, when reviewing the data, one must account for individual day-to-day variation $VO_{2max}$ of between 4-6% in individuals with no known cardiopulmonary pathology.[1]

## Future Research

In order to investigate the effect of age, a significantly larger subject population would be needed. This would be one of the single largest factors to allow possible generalization of results to the public. Random sampling within a larger geographical area would yield more applicable results as well. Ideally, both initial and final tests would be completed using the same equipment and software to ensure consistency between trials. Further research should also aim to create a method of controlling a subject's level of activity outside of the study. Finally, additional research could be constructed to explore the rate of injury from participation in a HIIT exercise regimen versus participation in a CT exercise regimen, with age specific analysis.

## - **CONCLUSIONS** -

Participation in any form of cardiovascular exercise, regardless of HIIT or CT, results in improved cardiovascular health, as outlined in this study. For individuals looking to begin exercising, CT may be the best mode of exercise based on the overall trends and results from this study in regards to increased exercise time and subsequently increased $VO_{2max}$. Participation in HIIT cannot be discouraged based on this study's results, as individuals from this group illustrated trends toward improvement in exercise time and $VO_{2max}$. With continued research, HIIT may evolve into a mode of exercise that is applied to a more diverse population, rather than constricting its applicability to athletes and individuals with specific pathologies. Members of the healthcare team may have an additional intervention in the not so distant future, backed by evidence, to suggest to their otherwise healthy patients in order to promote a healthier lifestyle.

# TABLES

*Table 1 – Bruce Protocol Treadmill Test*

| Stage | Speed (mph) | Grade (%) | Duration in Stage (min) | Total Elapsed Time (min) |
|---|---|---|---|---|
| 1 | 1.7 | 10 | 3 | 3 |
| 2 | 2.5 | 12 | 3 | 6 |
| 3 | 3.4 | 14 | 3 | 9 |
| 4 | 4.2 | 16 | 3 | 12 |
| 5 | 5.0 | 18 | 3 | 15 |
| 6 | 5.5 | 20 | 3 | 18 |

*Table 2 – Equipment*

| **General Equipment (used at initial & final)** | **Initial Testing Equipment** | **Final Testing Equipment** |
|---|---|---|
| American Diagnostic Corporation (ADC) portable stand-up manual sphygmomanometer | AEI Technologies 3 L calibration syringe | CosMed 3 L calibration syringe |
| Healthometer traditional balance-beam physician scale | Quinton MedTrack ST6 Treadmill | TrackMaster Treadmill |
| RPE visual-aid chart | Cardiac Science Quinton Q-Stress cart & 12-lead EKG | CosMed Quark Cardiovascular Pulmonary Exercise Testing (CPET) cart |
| Accu-Chek Nano glucometer | AEI Technologies Moxus Modular VO2 System: Oxygen analyzer S-38/I & Carbon dioxide analyzer CD-38 | CosMed Quark – PFT Ergo version 10.0b analysis software |
| Accu-Chek FastClix lancets | AEI Technologies 2 tubing inspiratory/expiratory system | COSMED VO2max digital flowmeter |
| Latex gloves | AEI Metabolic System Software – Moxus Max 2 | Calibration gas mixtures: (1) 16.00% $O_2$ & 3.987% $CO_2$; (2) 21.01% $O_2$ & .03% $CO_2$ |
| Covidien Webcol Alcohol prep – 2 ply medium | Calibration gas mixtures: (1) 16.00% $O_2$ & 3.987% $CO_2$; (2) 21.01% $O_2$ & .03% $CO_2$ | Hans Rudolph V2mask & soft head strap |
| Biodynamics Bioimpedance Analyzer – BIA 310e | AEI Technologies mouthpiece, headgear, & nose plug | |
| Polar HR monitors & watches | | |
| Respironics Go2 Fingertip Pulse Oximeter | | |
| 3M Littman Select stehoscope | | |

*Table 3 – $VO_{2max}$ Percent Change (initial to final) by Age*

| Age | HIIT Group | CT Group |
|---|---|---|
| 18-23 years old | HIIT2 = + 4.651% | CT1 = + 13.64%<br>CT3 = + 25.328% |
| 24-29 years old | HIIT3 = + 23.57%<br>HIIT4 = + 12.746%<br>HIIT5 = + 10.005% | CT2 = + 8.825%<br>CT4 = + 8.678% |
| 30-35 years old | HIIT1 = - 27.722% | CT5 = + 9.765% |
| 36+ years old | HIIT6 = + 4.721% | CT6 = + 2.484%<br>CT7 = + 24.065% |

*Table 4 – By >75% Compliance (regardless of age)*

| Subject | % Increase | Subject | % Increase |
|---|---|---|---|
| HIIT1 | - 27.722 % | CT1 | + 13.64% |
| HIIT2 | + 4.651% | CT2 | + 8.825% |
| HIIT4 | + 12.746% | CT5 | + 9.765% |
| HIIT6 | + 4.721% | CT7 | + 24.065% |

*Table 5 – Descriptive Statistics*

**Descriptive Statistics**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| HITCT | 13 | 0 | 1 | .54 | .519 |
| Gender | 13 | .00 | 1.00 | .6154 | .50637 |
| Age | 13 | 21.00 | 44.00 | 29.6154 | 7.57780 |
| MaxHR | 13 | 177.00 | 193.00 | 186.8462 | 5.22568 |
| RFPARQ | 13 | .00 | 1.00 | .4615 | .51887 |
| HR | 13 | 48.00 | 92.00 | 66.9231 | 12.33195 |
| SBP | 13 | 102.00 | 132.00 | 117.9231 | 9.95374 |
| DBP | 13 | 62.00 | 88.00 | 74.4615 | 9.42174 |
| OX | 13 | 97.00 | 100.00 | 98.3077 | .94733 |
| HT | 13 | 165.10 | 193.04 | 175.4077 | 10.51483 |
| WT | 13 | 57.15 | 102.06 | 73.4446 | 13.45632 |
| BMI | 13 | 19.60 | 29.10 | 23.7000 | 3.08031 |
| BIA | 13 | 16.10 | 39.40 | 24.2923 | 6.54949 |
| GLU | 13 | 86.00 | 140.00 | 102.3077 | 13.87675 |
| EXTIME | 13 | 9.50 | 12.93 | 11.1077 | 1.09511 |
| VO2 | 13 | 32.11 | 46.44 | 38.7300 | 4.59264 |
| HRF | 13 | 46.00 | 95.00 | 69.3846 | 15.41395 |
| SBPF | 13 | 108.00 | 138.00 | 120.0000 | 10.19804 |
| DBPF | 13 | 64.00 | 86.00 | 75.3846 | 8.34205 |
| OXF | 13 | 97.00 | 100.00 | 98.7692 | .92681 |
| HTF | 13 | 165.10 | 193.04 | 175.4077 | 10.51483 |
| WTF | 13 | 54.40 | 97.52 | 72.7423 | 13.04885 |
| BMIF | 13 | 19.10 | 29.80 | 23.5846 | 3.20906 |
| BIAF | 13 | 18.40 | 39.20 | 23.7000 | 6.15603 |
| GLUF | 13 | 84.00 | 111.00 | 100.0000 | 7.77817 |
| EXTIMEF | 13 | 7.52 | 14.15 | 11.9477 | 1.74475 |
| VO2FINAL | 13 | 24.82 | 51.59 | 42.3569 | 7.12109 |
| HITCT = 1 (FILTER) | 13 | 0 | 1 | .54 | .519 |
| Valid N (listwise) | 13 | | | | |

*HIITCT*: where 0 = HIIT group, where 1 = CT group;
*Gender*: where 0 = male, where 1 = female

*Table 6 Mann-Whitney U Test for CT vs. HIIT – Initial Testing*

**Ranks**

| | HITCT | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HR | 0 | 6 | 7.83 | 47.00 |
| | 1 | 7 | 6.29 | 44.00 |
| | Total | 13 | | |
| SBP | 0 | 6 | 5.08 | 30.50 |
| | 1 | 7 | 8.64 | 60.50 |
| | Total | 13 | | |
| DBP | 0 | 6 | 7.33 | 44.00 |
| | 1 | 7 | 6.71 | 47.00 |
| | Total | 13 | | |
| BIA | 0 | 6 | 7.75 | 46.50 |
| | 1 | 7 | 6.36 | 44.50 |
| | Total | 13 | | |
| EXTIME | 0 | 6 | 5.42 | 32.50 |
| | 1 | 7 | 8.36 | 58.50 |
| | Total | 13 | | |
| VO2 | 0 | 6 | 5.50 | 33.00 |
| | 1 | 7 | 8.29 | 58.00 |
| | Total | 13 | | |

**Test Statistics[a]**

| | HR | SBP | DBP | BIA | EXTIME | VO2 |
|---|---|---|---|---|---|---|
| Mann-Whitney U | 16.000 | 9.500 | 19.000 | 16.500 | 11.500 | 12.000 |
| Wilcoxon W | 44.000 | 30.500 | 47.000 | 44.500 | 32.500 | 33.000 |
| Z | -.714 | -1.654 | -.287 | -.644 | -1.359 | -1.286 |
| Asymp. Sig. (2-tailed) | .475 | .098 | .774 | .520 | .174 | .199 |
| Exact Sig. [2*(1-tailed Sig.)] | .534[b] | .101[b] | .836[b] | .534[b] | .181[b] | .234[b] |

a. Grouping Variable: HITCT

b. Not corrected for ties.

\

*Table 7 – Wilcoxon Signed-Rank Test for HIIT Group*:

**Ranks**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HRF - HR | Negative Ranks | 1[a] | 2.00 | 2.00 |
| | Positive Ranks | 3[b] | 2.67 | 8.00 |
| | Ties | 2[c] | | |
| | Total | 6 | | |
| SBPF - SBP | Negative Ranks | 3[d] | 2.00 | 6.00 |
| | Positive Ranks | 2[e] | 4.50 | 9.00 |
| | Ties | 1[f] | | |
| | Total | 6 | | |
| DBPF - DBP | Negative Ranks | 3[g] | 2.00 | 6.00 |
| | Positive Ranks | 2[h] | 4.50 | 9.00 |
| | Ties | 1[i] | | |
| | Total | 6 | | |
| OXF - OX | Negative Ranks | 1[j] | 2.00 | 2.00 |
| | Positive Ranks | 1[k] | 1.00 | 1.00 |
| | Ties | 4[l] | | |
| | Total | 6 | | |
| HTF - HT | Negative Ranks | 0[m] | .00 | .00 |
| | Positive Ranks | 0[n] | .00 | .00 |
| | Ties | 6[o] | | |
| | Total | 6 | | |
| WTF - WT | Negative Ranks | 4[p] | 3.38 | 13.50 |
| | Positive Ranks | 2[q] | 3.75 | 7.50 |
| | Ties | 0[r] | | |
| | Total | 6 | | |
| BMIF - BMI | Negative Ranks | 2[s] | 2.50 | 5.00 |
| | Positive Ranks | 2[t] | 2.50 | 5.00 |
| | Ties | 2[u] | | |
| | Total | 6 | | |
| BIAF - BIA | Negative Ranks | 4[v] | 3.50 | 14.00 |
| | Positive Ranks | 2[w] | 3.50 | 7.00 |
| | Ties | 0[x] | | |
| | Total | 6 | | |
| GLUF - GLU | Negative Ranks | 2[y] | 5.00 | 10.00 |
| | Positive Ranks | 4[z] | 2.75 | 11.00 |
| | Ties | 0[aa] | | |
| | Total | 6 | | |
| EXTIMEF - EXTIME | Negative Ranks | 1[ab] | 6.00 | 6.00 |
| | Positive Ranks | 5[ac] | 3.00 | 15.00 |
| | Ties | 0[ad] | | |
| | Total | 6 | | |
| VO2FINAL - VO2 | Negative Ranks | 1[ae] | 5.00 | 5.00 |
| | Positive Ranks | 5[af] | 3.20 | 16.00 |
| | Ties | 0[ag] | | |
| | Total | 6 | | |

**Test Statistics[a]**

| | HRF - HR | SBPF - SBP | DBPF - DBP | OXF - OX | HTF - HT | WTF - WT | BMIF - BMI | BIAF - BIA | GLUF - GLU | EXTIMEF - EXTIME | VO2FINAL - VO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Z | -1.095[b] | -.405[b] | -.405[b] | -.447[c] | .000[d] | -.631[c] | .000[d] | -.734[c] | -.105[b] | -.943[b] | -1.153[b] |
| Asymp. Sig. (2-tailed) | .273 | .686 | .686 | .655 | 1.000 | .528 | 1.000 | .463 | .917 | .345 | .249 |

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

c. Based on positive ranks.

d. The sum of negative ranks equals the sum of positive ranks.

*Table 8 – Wilcoxon Signed-Rank Test for CT Group*:

**Ranks**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HRF - HR | Negative Ranks | 4[a] | 3.75 | 15.00 |
| | Positive Ranks | 3[b] | 4.33 | 13.00 |
| | Ties | 0[c] | | |
| | Total | 7 | | |
| SBPF - SBP | Negative Ranks | 3[d] | 4.17 | 12.50 |
| | Positive Ranks | 4[e] | 3.88 | 15.50 |
| | Ties | 0[f] | | |
| | Total | 7 | | |
| DBPF - DBP | Negative Ranks | 2[g] | 4.00 | 8.00 |
| | Positive Ranks | 4[h] | 3.25 | 13.00 |
| | Ties | 1[i] | | |
| | Total | 7 | | |
| OXF - OX | Negative Ranks | 1[j] | 2.00 | 2.00 |
| | Positive Ranks | 5[k] | 3.80 | 19.00 |
| | Ties | 1[l] | | |
| | Total | 7 | | |
| HTF - HT | Negative Ranks | 0[m] | .00 | .00 |
| | Positive Ranks | 0[n] | .00 | .00 |
| | Ties | 7[o] | | |
| | Total | 7 | | |
| WTF - WT | Negative Ranks | 3[p] | 4.00 | 12.00 |
| | Positive Ranks | 2[q] | 1.50 | 3.00 |
| | Ties | 2[r] | | |
| | Total | 7 | | |
| BMIF - BMI | Negative Ranks | 3[s] | 4.00 | 12.00 |
| | Positive Ranks | 2[t] | 1.50 | 3.00 |
| | Ties | 2[u] | | |
| | Total | 7 | | |
| BIAF - BIA | Negative Ranks | 5[v] | 3.80 | 19.00 |
| | Positive Ranks | 2[w] | 4.50 | 9.00 |
| | Ties | 0[x] | | |
| | Total | 7 | | |
| GLUF - GLU | Negative Ranks | 3[y] | 3.00 | 9.00 |
| | Positive Ranks | 3[z] | 4.00 | 12.00 |
| | Ties | 1[aa] | | |
| | Total | 7 | | |
| EXTIMEF - EXTIME | Negative Ranks | 0[ab] | .00 | .00 |
| | Positive Ranks | 7[ac] | 4.00 | 28.00 |
| | Ties | 0[ad] | | |
| | Total | 7 | | |
| VO2FINAL - VO2 | Negative Ranks | 0[ae] | .00 | .00 |
| | Positive Ranks | 7[af] | 4.00 | 28.00 |
| | Ties | 0[ag] | | |
| | Total | 7 | | |

**Test Statistics[a]**

| | HRF - HR | SBPF - SBP | DBPF - DBP | OXF - OX | HTF - HT | WTF - WT | BMIF - BMI | BIAF - BIA | GLUF - GLU | EXTIMEF - EXTIME | VO2FINAL - VO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Z | -.169[b] | -.254[c] | -.524[c] | -1.823[c] | .000[d] | -1.214[b] | -1.219[b] | -.847[b] | -.314[c] | -2.366[c] | -2.366[c] |
| Asymp. Sig. (2-tailed) | .866 | .799 | .600 | .068 | 1.000 | .225 | .223 | .397 | .753 | .018 | .018 |

a. Wilcoxon Signed Ranks Test

b. Based on positive ranks.

c. Based on negative ranks.

d. The sum of negative ranks equals the sum of positive ranks.

*Table 9 Mann-Whitney U Test for CT vs. HIIT – Final Testing*

**Ranks**

| | HITCT | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HRF | 0 | 6 | 7.75 | 46.50 |
| | 1 | 7 | 6.36 | 44.50 |
| | Total | 13 | | |
| SBPF | 0 | 6 | 6.75 | 40.50 |
| | 1 | 7 | 7.21 | 50.50 |
| | Total | 13 | | |
| DBPF | 0 | 6 | 7.17 | 43.00 |
| | 1 | 7 | 6.86 | 48.00 |
| | Total | 13 | | |
| BIAF | 0 | 6 | 8.17 | 49.00 |
| | 1 | 7 | 6.00 | 42.00 |
| | Total | 13 | | |
| EXTIMEF | 0 | 6 | 5.33 | 32.00 |
| | 1 | 7 | 8.43 | 59.00 |
| | Total | 13 | | |
| VO2FINAL | 0 | 6 | 5.33 | 32.00 |
| | 1 | 7 | 8.43 | 59.00 |
| | Total | 13 | | |

**Test Statistics[a]**

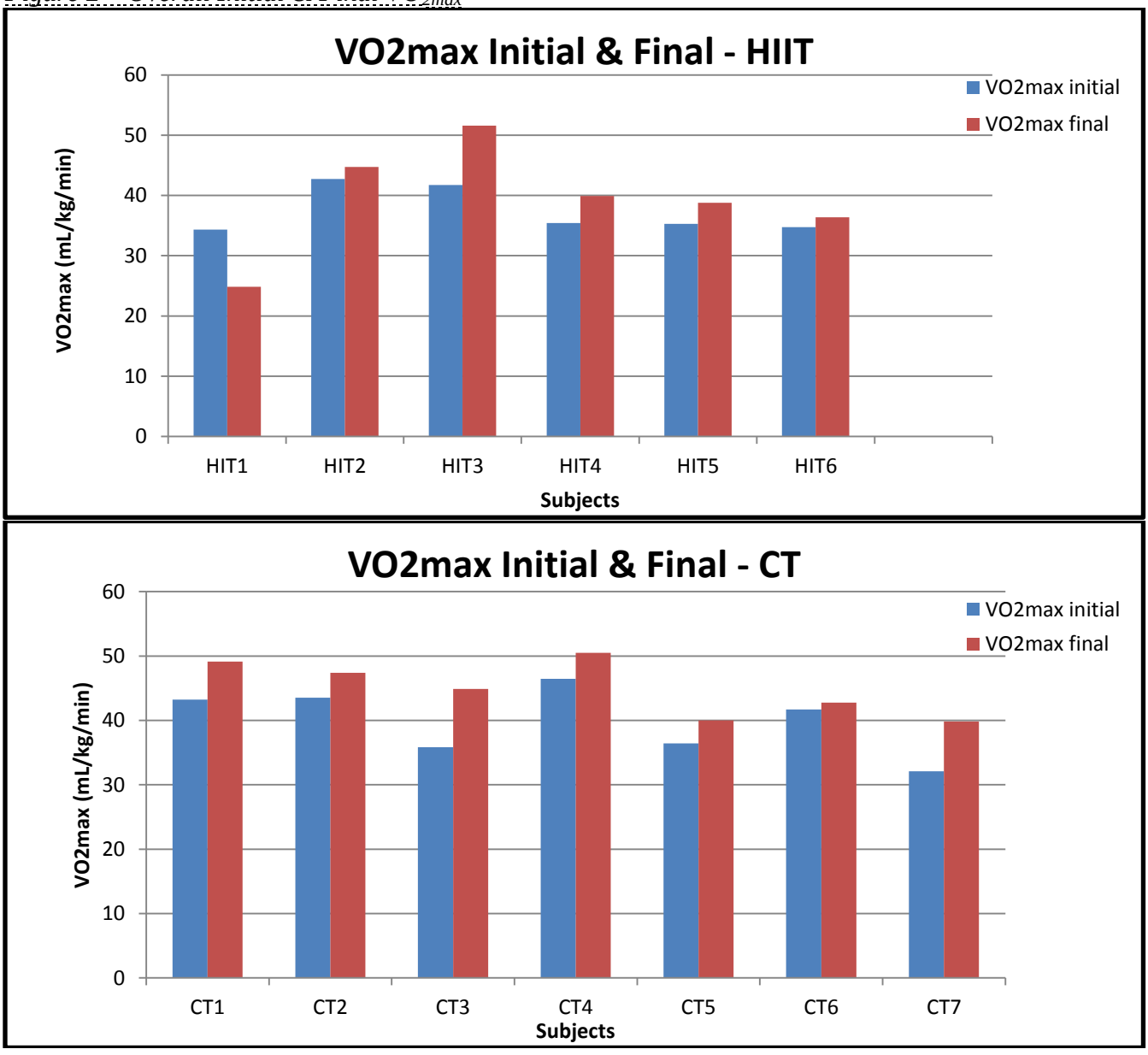
| | HRF | SBPF | DBPF | BIAF | EXTIMEF | VO2FINAL |
|---|---|---|---|---|---|---|
| Mann-Whitney U | 16.500 | 19.500 | 20.000 | 14.000 | 11.000 | 11.000 |
| Wilcoxon W | 44.500 | 40.500 | 48.000 | 42.000 | 32.000 | 32.000 |
| Z | -.647 | -.218 | -.144 | -1.000 | -1.429 | -1.429 |
| Asymp. Sig. (2-tailed) | .517 | .828 | .886 | .317 | .153 | .153 |
| Exact Sig. [2*(1-tailed Sig.)] | .534[b] | .836[b] | .945[b] | .366[b] | .181[b] | .181[b] |

a. Grouping Variable: HITCT

b. Not corrected for ties.

# FIGURES

*Figure 2 – Overall Initial & Final $VO_{2max}$*



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# APPENDICES

*Appendix 1. Interview Questions for Pre-Participation Screening – deduced from ACSM 8th ed.*

**Diagnosis**

- Cardiovascular
    - Have you been diagnosed by a physician with any of the following conditions: cardiac, peripheral artery, or cerebrovascular disease?
- Pulmonary
    - Have you been diagnosed by a physician with any of the following conditions: chronic obstructive pulmonary disease, asthma, interstitial lung disease, or cystic fibrosis?
- Metabolic disease
    - Have you been diagnosed by a physician with any of the following conditions: diabetes mellitus type 1 or 2, thyroid disorders, renal or liver disease?

**Major Signs and Symptoms**

- Pain, discomfort (or other anginal equivalent) in the chest, neck, jaw, arms, or other areas that may result from ischemia
    - Do you experience squeezing or heaviness in any areas aforementioned?
    - Do you experience any knife-like or sharp pains aggravated by respiration?
- Shortness of breath at rest or with mild exertion
    - Do you ever experience any abnormal uncomfortable breathing?
- Dizziness or syncope
    - Do you ever experience any dizziness or loss of consciousness during or immediately after exercise?
- Orthopnea or paroxysmal nocturnal dyspnea
    - Do you ever experience any abnormally uncomfortable breathing while lying down that is relieved by sitting or standing up?
    - Do you ever experience uncomfortable breathing 2-5 hours after the onset of sleep?
- Ankle swelling
- Palpitations or tachycardia
    - Do you ever experience any unpleasant forceful or rapid beating of the heart?
    - Does your heart ever "skip a beat"?
- Intermittent claudication
    - Do you ever experience a cramp-like feeling in the legs which disappears within 1-2 minutes of stopping exercise?
- Known heart murmur
    - Have you ever been told by a physician that you have a heart murmur?
- Unusual fatigue or shortness of breath with daily activities

**Cardiovascular Disease Risk Factors**

- Age
    - Are you a male age 45 or older a female age 55 or older?
- Family history
    - Has/did your father or any other immediate male relative ever experienced any of the following before age 55:

        - Myocardial infarction (heart attack)? Coronary revascularization (open heart surgery)? Sudden death?
    - Has/did you mother or any other immediate female relative ever experienced any of the following before age 65:
        - Myocardial infarction (heart attack)? Coronary revascularization (open heart surgery)? Sudden death?
- Cigarettes and Smoking
    - Are you a current cigarette smoker? Or have you quit within the previous 6 months?
    - Are you consistently exposed to environmental tobacco smoke?
- Sedentary lifestyle
    - Do you participate in at least 30 minutes of moderate intensity physical activity on at least 3 days of the week for at least 3 months?
- Obesity
    - Is your BMI > 30 $kgm^2$?
    - Is your waist circumference > 40 in (men) or 45 in (female)?
- Hypertension
    - Is your systolic blood pressure > than or = to 140 mmHg?
    - Is your diastolic blood pressure > or = 90 mmHg? (Confirmed on two separate occasions)
    - Are you on antihypertensive medication?
- Dyslipidemia
    - Are you on lipid lowering medication?
    - Have you ever been told that you have high cholesterol?
- Prediabetes
    - Is your fasting glucose greater than or equal to 100 mg/dL but less than 126 mg/dL?

*Appendix 2. Par-Q & You*

Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

# PAR-Q & YOU

**(A Questionnaire for People Aged 15 to 69)**

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

| YES | NO | |
|---|---|---|
| ☐ | ☐ | **1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?** |
| ☐ | ☐ | **2. Do you feel pain in your chest when you do physical activity?** |
| ☐ | ☐ | **3. In the past month, have you had chest pain when you were not doing physical activity?** |
| ☐ | ☐ | **4. Do you lose your balance because of dizziness or do you ever lose consciousness?** |
| ☐ | ☐ | **5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?** |
| ☐ | ☐ | **6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?** |
| ☐ | ☐ | **7. Do you know of any other reason why you should not do physical activity?** |

## If you answered

## YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

## NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

**DELAY BECOMING MUCH MORE ACTIVE:**

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

**PLEASE NOTE:** If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

**No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.**

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME _____

SIGNATURE _____ DATE _____

SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority) _____ WITNESS _____

**Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.**

*Appendix3 AHA/ACSM Health/Fitness Facility Pre-participation Screening Questionnaire*

**AHA/ACSM Health/Fitness Facility Pre-participation Screening Questionnaire**

**Assess your health status by marking all true statements**

**History**

You have had:

_____ a heart attack
_____ heart surgery
_____ cardiac catheterization coronary
_____ angioplasty (PTCA)
_____ Pacemaker/implantable cardiac defibrillator
_____ rhythm disturbance
_____ heart valve disease
_____ heart failure
_____ heart transplantation
_____ congenital heart disease

Symptoms:

_____ You experience chest discomfort with exertion.
_____ You experience unreasonable breathlessness
_____ You experience dizziness, fainting, or blackouts
_____ You take heart medications

Other health issues

_____ You have diabetes
_____ You have asthma or other lung disease
_____ You have burning or cramping sensation in your lower legs when walking short distances
_____ You have musculoskeletal problems that limit your physical activity.
_____ You have concerns about the safety of exercise
_____ You take prescription medication(s).
_____ You are pregnant.

**If you marked any of these statements in this section, consult your physician or other appropriate health tare provider before engaging in exercise. You may reed to use a facility with a medically qualified staff.**

**Cardiovascular risk factors**

_____ You are a man older than 45 years.
_____ You are a woman older than 55 years, have had a hysterectomy, or are postmenopausal
_____ You smoke, or quit smoking within the previous 6 months.
_____ Your blood pressure is >140190 mm Hg.
_____ You do not know your blood pressure.
_____ You take blood pressure medication.
_____ Your blood cholesterol level is >200 mg/dl.
_____ You do not know your cholesterol level.

---

_____ You have a close blood relative who had a heart attack or heart surgery before age 55 (father or brother) or age 65 (mother or sister).
_____ You are physically inactive (i.e., you get <30 minutes of physical activity on at least 3 days per week).
_____ You are >20 pounds overweight

**If you marked two or more of the statements in this section you should consult you physician or other appropriate health rare provider before engaging in exercise. You might benefit from using a facility with a professionally qualified exercise staff to guide your exercise Program.**

_____ None of the above

*Appendix 4. Treadmill Exercise Protocols*

- *HIIT group:*
    - 5 minute warm-up on the treadmill (TM) at 30% $HR_{reserve}$
    - 1 minute passive recovery interval before initiation of the HIIT session
        - Passive was defined as completely stationary (off the TM)
    - Initiation of 25 minute HIIT session:
        - Running on TM at 80-90% $HR_{reserve}$ for 1 minute
        - Followed by 1 minute of passive recovery
            - Repeat pattern until 25 minutes of exercise is complete
            - Total work time = 13 minutes; Total passive recovery time = 12 minutes
    - 3 minute cool-down on the TM at 30% $HR_{reserve}$
- *CT group:*
    - 5 minute warm-up on the treadmill (TM) at 30% $HR_{reserve}$
    - 1 minute passive recovery interval before initiation of the CT session
        - Passive was defined as completely stationary (off the TM)
    - Initiation of 40 minute CT session:
        - Run/walk on TM at 55-65% $HR_{reserve}$ for 40 min
            - Total work time = 40 minutes
    - 3 minute cool-down on the TM at 30% $HR_{reserve}$