High Intensity Interval Training as Means to Reduce Symptoms of

Metabolic Syndrome

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Abstract

In 2006, 34% of adults in America met the criteria for Metabolic Syndrome (MetSyn), with men and women 40-59 years of age having triple the chance of meeting the criteria than younger adults (Ervin, 2009).

Purpose - The purpose of this study was to examine the effects of High Intensity Interval Training (HIIT) on the symptoms of MetSyn in women 40-65 years of age.

Methods - Volunteers were solicited from Durango, CO and surrounding communities for participation in this study. Participants were randomly assigned to a study group (SG)(n=11) or control (CG)(n=11). All participants were measured for waist circumference (WC), blood pressure (BP), triglycerides (TG), high-density lipoproteins (HDL), and fasting glucose (FG). The SG exercised with body weight only four times a week for six weeks. Each session included three sets using the same exercises but with intensity increasing by speed of execution. The CG maintained their lifestyle and attended measuring sessions.

Results - Systolic (SBP) and diastolic (DBP) blood pressure did not statistically improve ($p=0.121$ and $p=0.316$ respectively). FG ($p=0.784$) and HDL ($p=0.085$) measures did not improve. Waist circumference did not significantly improve ($p=0.148$) yet there was improvement in the SG means.   TG showed significant improvement ($p=0.023$).

Conclusion - Despite the change in TG as a result of this six-week study, HIIT did not significantly reduce all the symptoms of MetSyn in women 40-65 years of age.

INTRODUCTION

As the frequency of insulin resistance diagnoses increase, so too do the instances of other metabolic irregularities occur as a result of decreased glucose tolerance. This group of abnormalities is now referred to as Metabolic Syndrome (MetSyn).). In 2008, a MetSyn diagnosis was defined as the presence of three or more of the five symptoms (Alberti & Zimmet, 2009). These criteria include abnormalities in blood pressure (BP), waist circumference (WC), serum glucose and lipids. According to the National Institute of Health, "incidence of the metabolic syndrome and its associated increase in cardiometabolic risk has reached pandemic proportions." (Irving, et al., 2008, p. 1864). Most recently reported: "Twenty-one percent of the population age 60 and older – 10.3 million people – have diabetes" (Aging, 2012, ¶ 1). Since the diagnosis of MetSyn indicates a predisposition for diabetes, all strategies, including diet, exercise and stress reduction need to be addressed in order to slow, or conceivably stop, the progression of the syndrome.

Over sixty years ago, a concept was proposed regarding the location of body fat making a difference in the likelihood of the development of metabolic disease (Matsuzawa, 2008). The android (apple shaped) individual stood a greater chance of developing disease than the gynoid (pear shaped) (Matsuzawa, 2008). In 1985, further clarification as central (upper body) and peripheral (lower body) obesity proposed that central obesity was more likely to carry the burden of disease (Matsuzawa, 2008). In 1983 in Japan, using computed tomography (CT), central fat was further defined as two distinct types, visceral and subcutaneous (Matsuzawa, 2008).

Subcutaneous abdominal fat is located in two different areas, the superficial and deep layers partitioned by the fascia superficialis (Rattarasarn, 2006). Visceral fat (VF) on the other hand, is found in the abdominal cavity and is made of both omental and mesenteric fat (Rattarasarn, 2006). By performing liposuction of the subcutaneous area of adipose tissue in 2004, insulin sensitivity or other risk factors for coronary heart disease, including blood pressure, plasma glucose, insulin or lipid concentrations were unaffected (Klein, et al., 2004). The adipokines that reside within VF are what influence insulin resistance (Rattarasarn, 2006). Whether not the removal of visceral fat in men or women will improve insulin sensitivity is unknown (Rattarasarn, 2006).

Women's visceral fat tends to dramatically increase in menopause (Matsuzawa, 2008). The reduction of Body Mass Index (BMI), Triglycerides (TG) and WC combined with increase in High Density Lipoproteins (HDL) in premenopausal and perimenopausal women using moderate endurance training (Hagner, Hagner-Derengowska, Wiacek, & Zubryzycki, 2009) has been established in their 12-week study. In another 12-week study TG, HDL-C, waist-hip-ratio (WHR), fasting levels of glucose, and BP showed improvement in obese middle-aged women using a combined resistance and aerobic exercise training program (Seo, et al., 2011).
Exercising with HIIT has been shown in numerous studies to reduce abdominal fat due to the exercise "inducing secretion of lipolytic hormones including growth hormone and epinephrine which may facilitate greater post-exercise energy expenditure and fat oxidation" (Irving, et al., 2008, p. 1864).

"There was a significant correlation between central abdominal fat loss and change in insulin concentration with training (r=0.46, P<0.05) so that individuals who lost more abdominal fat had a greater decrease in fasting insulin concentration" (Trapp et al., 2008, p. 688). Given the nature of visceral obesity and that it, along with "hyperinsulinemia and insulin resistance, not only accompanies but antedates the components of the metabolic syndrome" (Ibrahim, 2009, p. 15), it would seem that any increase in exercise or physical activity would prove beneficial. Given these optimistic results it can be postulated that HIIT alone may produce positive effects in the reduction of abdominal fat and MetSyn symptoms in perimenopausal women.

METHODOLOGY

Selection of Participants

Non-probability sampling procedures were used to select participants (n22). Using simple random sampling from the 22 volunteer participants, half (n11) were assigned as the study group (SG) and half (n11) to the control group (CG). The CG was asked to keep a journal of their chosen exercise activity for the duration of the study. Inclusion criteria included apparently healthy females between the ages of 40-65 years of age determined to be of low/moderate risk factors (≥ 2 risk factors for heart disease) as defined by the ACSM (Green M. , 2010, p. 24). Given that "Menopause is closely related to abdominal obesity and associated with a 60% increased risk of MetSyn," (Quader et al., 2008, p.476), the age for the participants for this study was easily defined. A comprehensive health history questionnaire was used to assess risk factors.

Collection of demographic information was accomplished via questionnaire that includes the status of menopause that was categorized as Premenopausal (last period less than 60 days prior), Menopausal Transition (last period 60-365 prior to testing) and Postmenopausal (final period more than 365 days prior to testing) (Hagner et al., 2009), use of hormone replacement therapy (HRT) as well as exercise history. At that time, an identifying code was assigned to each participant so as to insure confidentiality from this point forward. Those potential participants who have smoked within the past 5 years were excluded from this study due to the effect of smoking of increased heart rate and decreased VO_{2peak} (Mendonca, Pereira, & Fernhall, 2011).

Duration

The duration of the study was seven weeks with the initial week used to identify participants and to acquire their baseline measurements. The actual exercise portion of the study was 6 weeks in length, four times a week.

Measurements.

Participants were asked to refrain from eating or drinking anything but water within 12 hours before their measurements were taken. A CardioCheck PA meter was used to test for initial metabolic profile to reveal fasting HDL, TG and Glucose. Reliability of instrument has been demonstrated at 2.4% error for total cholesterol

and 3.7% error for HDL (Polymer Technology Systems, 2011). Using a tape measure and a scale other baseline measurements included WC measured at the midpoint between the iliac crest and the last rib, hip measurements at fullest part of the hips and buttocks, weight in pounds (lbs.) and waist-to-hip ratio (WHR) calculations. Blood pressure was measured by volunteer nurse or Certified Nursing Assistant (CNA) using manual a stethoscope and sphygmomanometer. In the case those individuals are not available due to scheduling, a digital blood pressure monitor (Omron) was used. Half way through the study, on exercise day 12 (Friday, February 1), fasting lipid and glucose readings were taken again as well as waist circumference and weight. Final measurements were taken within four days of the participants' final class. Both CG and SG were tested for all measurement data.

Estimated VO_2max results to establish fitness levels were determined using the Rockport Fitness Walking Test (RFWT) (Heyward, 2006) protocol for a one-mile track walk. Regarding validity of the RFWT, "The correlation (r) between predicted VO_2max and actual VO_2max was 0.93 (SEE=0.325 L•min $^{-1}$)" (Noonan & Dean, 2000, p. 792). The RFWT was performed indoors with both SG and CG during the initial measuring week and repeated the within four days of the final class.

Exercise

Eight body weight exercises (i.e. jumping jacks, squats, football runs) were performed for 30 seconds each in three sets of four minutes with intensity each set progressively more difficult according to protocol of the PACE Express program (Sears, 2012). The eight exercises each session were selected from thirty two exercises using only body weight. Participants were asked to use the Borg Rate of Perceived Exertion (RPE) Scale in addition to taking their own heart rate via tactile palpation of either the radial or carotid artery before, during and after exercise sessions. According to Gunnar Borg (1998), the RPE scale and HR correlations have been reported at 0.80 for aerobic work performed on a treadmill. Participants were instructed to reach levels of 11 (Light), 13-15 (Somewhat Hard - Hard) and 18 (Very Hard) on the 6-20 rating of the RPE scale in each consecutive set. Heart rates were taken and noted before exercise, immediately after each set, after a one minute recovery after the first two sets and a two minute recovery after the third set. RPE's were noted after each set. A cool down/stretching period concluded each exercise session consisting of slow walking around the exercise room and static calf stretches.

Data Collection

Measurement data was collected during measuring sessions on a slip carried by the participant then transferred to computer in a password protected Excel spreadsheet. Exercise data of heart rates and RPE ratings were collected via form issued to each participant before sessions and collected immediately after. To insure confidentiality, a code for each participant's identification (ID) was noted on the form. Hand-written sheets were destroyed upon completion of study as was all identifying information. Only raw data was maintained for further analysis. On the last day of testing, all participants were asked to fill out a questionnaire to identify

their physical activity/exercise for the previous six weeks as well as what type of food or diet they may have followed.

Statistical Analysis

Repeated measure ANOVA was used to analyze each of the five dependent variables that define the criteria of Metabolic Syndrome. Those criteria include waist girth (WG), fasting glucose levels (FG), HDL, TG, and BP.

Participant Characteristics

Each participant was required to fulfill the following inclusion criteria: be between the ages of 40-65, non-smoker, and sedentary (less than 1 hour of exercise per week), as well as the exclusion criteria of: not diagnosed with Cardiovascular or Pulmonary Disease or Diabetes Type I or II. The original 22 participants were all female, between the ages 42-62, (54.64 ± 4.88). They were divided into study group (SG) (n11) and control group (CG) (n11). Within the first week of the study, two of the SG withdrew due to illness and one was moved to the CG due to the distance of the drive necessary to reach the HIIT classes. In the middle of the study, one CG withdrew due to illness. In the final week of testing, one of the CG withdrew due to scheduling conflicts, one due to illness. Thus, there were eight SG (age 53.25 ± 5.18), and nine CG (age 54.78, ±5.56) participants that completed the study. Of those, ten were Postmenopausal with three of them on HRT and five were Transitional with two on HRT. Two did not complete the demographic survey. Descriptive characteristics of the participants are given in Table 1.

All 17 participants did attend the first and final measurement sessions. Due to one or more participants unable to attend the mid-way measuring event due to illness, the data was not used in the final analysis. During the study, the SG performed 18 of the 24 HIIT classes while the CG maintained their current lifestyle. Two of the 20 required classes were waived due to severe weather conditions.   The CG did minimal exercise if any during the study.

RESULTS

Data was analyzed using ANOVA repeated measures. Values are expressed as mean ± standard deviations in Tables 1 and 2. No analysis was performed to estimate the independent contribution of age, menopausal status, or HRT use. No significant improvement was noted for WC despite a 1.06" reduction in the means for the SG (p=0.148). Systolic and diastolic blood pressures were taken by a CNA and manual sphygmomanometer and blood pressure cuff in most instances. Due to scheduling conflicts, five final BPs were acquired by the researcher using an Omron digital blood pressure cuff. Results indicated no significant improvement in SBP readings (p=0.121), or DBP (p=0.316). The CardioCheck PA instrument was used in all FG, HDL and TG measures. There were no positive indicators for study effect in these measures with FG (p=0.784) or HDL (p=0.085). However, TG showed a significant effect (p=0.023). MetSyn factor related means are given in Table 2.

Table 1: Descriptive Characteristics of Participants. Test results outside of MetSyn factors pre- and post-test (means and standard deviation).

	Study Group		Control Group -	
	First Measure	Final Measure	First Measure	Final Measure
	n=8		n=9	
	μ (SD)	μ(SD)	μ (SD)	μ (SD)
Weight	161.25 (± 39.42)	160.63 (± 37.91)	159.06 (± 34.31)	159.78 (± 34.96)
Hip Circumference	42.75 (± 5.91)	41.38 (± 5.45)	42.81 (± 4.22)	42.64 (± 4.25)
Waist-Hip ratio	0.79 (± 0.10)	0.80 (±0.09)	0.78 (± 0.56)	0.78 (± 0.06)
Rockport Finish HR	113.25 (± 9.34)	136.25 (± 5.47)	117.78 (± 8.80)	122.00 (± 5.16)
Estimated VO2max	30.28 (± 2.84)	33.16 (± 2.24)	27.51 (± 2.68)	30.37 (± 2.11)
Age (years)	53.25 (± 5.18)		54.78 (±5.56)	
Menopause Status	4 - Transitional / 4-Post-Menopausal		1 -Transitional / 8 - Post-Menopausal	
Hormone Replacement Therapy (HRT)	1 - Yes / 7 - No		3 - Yes / 6 - No	

Table 2. Hypothesis related results – MetSyn factors. Pre- and post-test (means and standard deviation)..

	Study Group		Control Group -	
	First Measure	Final Measure	First Measure	Final Measure
	n=8		n=9	
	μ (SD)	μ(SD)	μ (SD)	μ (SD)
Systolic blood pressure (SBP)(mmHg)	119.5 (± 9.49)	113.00 (±16.20)	113.56 (± 12.52)	118.67 (±7.07)
Diastolic blood Pressure (DBP)(mmHg)	60.75 (± 2.61)	67.25 (±12.77)	64.00 (± 4.90)	65.22 (± 8.12)
Waist circumference (WC)(inches)	33.69 (± 7.32)	32.63 (±5.85)	33.28 (± 3.79)	34.17 (± 3.63)
Fasting blood glucose (FG) (mmol L^{-1})	82.75 (± 3.85)	81.38 (±7.67)	81.22 (± 5.33)	80.89 (± 8.923)
Fasting HDL Cholesterol (mmol L^{-1})	67.63 (± 18.71)	59.63 (±20.46)	72.89 (± 13.98)	55.22 (± 12.12)
Fasting Triglycerides (TG)(mmol L^{-1})	94.50 (± 32.26)	85.00 (±26.19)	83.67 (± 18.97)	125.78 (± 55.74)

DISCUSSION

Findings

Central obesity is the one risk factor that is shared by most patients diagnosed with Metabolic Syndrome (Alberti, Zimmet, & Shaw, 2006, as cited by Irving, et al., 2008). Though not statistically significant in this six week study (p> 0.05), waist circumference reduction of 1.06" in the SG mean (Table 2) due to HIIT exercise was a positive result. Using a Monarch bicycle to perform HIIT three times a week for fifteen weeks, Trapp, Chisholm, Freund, & Boutcher (2008) did reach a significant improvement (p< 0.05).

The ACSM (American College of Sports Medicine and the American Diabetes Association, 2010) reports that diet and regular physical activity can reduce blood pressure. SBP means improved slightly (Table 2). However, due to the variability of instruments to collect final BP data the analysis may be skewed. DBP readings slightly increased (Table 2). This again may be as a result of the varied testing methods. It should be noted here that the majority of participants experienced cold or flu symptoms and took medications to alleviate those symptoms for various periods throughout the study. This may have created confounding factors that may have influenced our SBP as well as DBP results.

The FG and HDL measures showed changes insignificant (p>0.05) in this six week study (Table 2). HDL measures showed slight decreases rather than increases in both groups (Table 2). Using combined medium intensity aerobic and strength training for 12 weeks, HDL (p=0.028), TG (p=0.02) and FG (p = 0.001) factors showed noteworthy improvement (Seo et al., 2011).

Using this protocol for HIIT, reduction of TG showed a significant effect (p=0.023). Despite meeting the requirement of a 12-hour fast before measuring, the variability of the range of TG means (Table 2) may be attributed to the content of the meal and/or alcohol ingestion before the fast commenced. Each individual's genetic propensity for metabolism of TG was not considered. However, in studies of longer duration and moderate intensity, TG were also reduced (p ≤ 0.05, Hagner et al.,2009).

Though not all the results in this study of MetSyn factors were found to be statistically significant with regard to the hypothesis, there were in fact notable improvements in other areas measured. Both SG and CG means improved by 2.8 ml/kg/min in estimated VO2max results (Table 1)(p=0.995). Because both groups improved to the same degree, it must be attributed to familiarity of task (RFWT) rather than the effect of HIIT. Weight loss for the SG means dropped 0.62 pounds while the CG gained 0.72 pounds (p=0.357). Hip circumference provided a significant improvement (p=0.031) with SG reducing means 1.37" and control only 0.17" (Table 1).

Conclusions

A plethora of programs to address the cardiometabolic implications of MetSyn have been developed. The simplest answer may be to begin with what seems to be the primary factor, abdominal obesity (Matsuzawa, 2008; Rattarasarn, 2006). It has been established that reducing intra-abdominal obesity is quite possible by adding moderate aerobic exercise to a structured low calorie diet (Okura, Nakata, Lee, Ohkawara, & Tanaka, 2005). Varying the intensity of exercise can also make a difference in reducing abdominal fat (Coker et al., 2009; Irving, et al., 2008).

Despite the reduction in means for the SG on WC (Table 2), it must be concluded that this six-week HIIT program did not significantly impact all of the five symptoms of MetSyn in women 40-65. However, the statistical data shows TG did improve using HIIT. The hypothesis has been rejected based on these results.

Implementations

MetSyn and all of its factors remain a growing concern for all populations and the future of healthcare. Aside from abdominal measures, studies point to the reduction of blood markers by applying a moderate intensity exercise program alone (Hagner et al., 2009) or with the addition of resistance exercise (Seo, et al., 2011). Given that many of these factors can be prevented or reversed with education of proper diet and exercise, the continued effort of research and application of findings must endure. All of this information and research shows positive momentum in the war against MetSyn. The missing piece seems to be the individualized education and attention that needs to be provided by individuals trained in exercise, nutrition and wellness.

Recommendations

In an effort to provide more meaningful results in this study using HIIT alone to reduce the symptoms of MetSyn, several aspects could be adjusted. One suggestion is using a more symptomatic population with a higher BMI or any of the indicators for MetSyn that are already out of healthy range such as: FG, BP and/or WC. This study was designed for six weeks due to time constraints of the semester. A longer study, perhaps 12-16 weeks may make a difference. A larger sample size could provide more significant data. Diet consideration and/or resistance exercise could be added, though both would confuse the effects of HIIT. An additional consideration is that the study should not be performed in cold and flu season to avoid complications from medications and reduced energy levels. Also, to get more reliable blood marker and blood pressure readings participants should be asked to abstain from alcohol, caffeine and vigorous physical activity for 24 hours prior to testing (Irving et al., 2008).

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