

CHAPTER 4: SUMMARY AND RECOMMENDATIONS

SUMMARY AND IMPLICATIONS

The present study compared MIT to HIIT as part of a nine week diet and exercise program for 13 obese men. Weekly group nutrition education sessions and modest calorie restriction (~500 kcal/day) were implemented in both exercise groups. Exercise began at 45% VO₂max for 20 minutes, increasing to 25 minutes during week one. During week two the intensity was increased to 50% VO₂max and duration to 30 minutes. The MIT protocol progressed to 65% VO₂max by week eight. The HIIT protocol consisting of 16 short, 8 medium, and 4 long intervals progressed to 110% VO₂max, 100% VO₂max, and 90% VO₂max, respectively by week nine with low intensity intervals at 40% VO₂max. Exercise duration of the MIT group was adjusted to allow for energy expenditure equal to that of the HIIT group. The exercise energy expenditure ranged from 250-350 kcal/session from the beginning to the end of the treatment period. Prior to and after diet and exercise treatment, body weight, %BF, FFM, FM, WHR, WTR, and waist circumference were determined. Additionally, a muscle biopsy was performed for analysis of HADH activity.

Subject number in this study was low, seven in the HIIT group and six in the MIT group. Of these 13 subjects, seven in the HIIT group and five in the MIT group had body composition determined. Additionally, only seven muscle samples were analyzed pre- and post-treatment for HADH activity (three in HIIT, four in MIT). These low numbers resulted in a high variability in the measurements and therefore a low statistical power. This may have adversely affected the results.

There were no significant changes in energy intake throughout the study duration. Weight decreased 2.6% in the MIT group and 2.8% in the HIIT group ($p < 0.05$). Diet and exercise treatment resulted in a 7% decrease in %BF and a 9% decrease in FM for the groups

combined, but not for either group individually. FFM did not change as a result of treatment. Overall, waist circumference decreased 2.8% ($p < 0.05$) with no differences between the groups. There were no differences in WHR or WTR for either group. The activity of HADH increased 37% and 97% ($p < 0.05$) for the MIT and HIIT groups respectively with a trend for differences between the two groups ($p = 0.055$).

The results indicate that MIT and HIIT when included as part of diet and exercise treatment are equally effective in reducing body weight, body fat, and waist circumference in obese men with decreased energy intake. HIIT may be more effective in the treatment of obesity over a longer period if the observed trend for greater capacity for muscle fat oxidation as denoted by HADH activity translates into improved body fat loss.

Although there were no statistically significant differences in energy intake over the treatment period, there was a detectable numerical difference in the MIT group. From baseline to week nine there was ~3000 kJ decrease in energy intake in MIT and only ~1300 kJ decrease in energy intake in HIIT. It is possible that the greater energy deficit found in the MIT group contributed to the subjects in the MIT group decreasing their %BF by 11% compared to the HIIT group who only decreased %BF by 4%.

In addition to the changes in energy intake, there was a trend ($p < 0.100$) for differences in macronutrient content from baseline to week nine for all subjects combined. Percent of calories from CHO increased from 52% to 58%, percent of calories from fat decreased from 29% to 22%, and percent of calories from protein increased from 17% to 19%. By the end of the treatment period the subjects were meeting the established dietary guidelines.

Another interesting comparison between the two treatment groups is that there was a trend for the HIIT group to decrease waist circumference greater than MIT ($p = 0.179$) and for the

MIT group to decrease %BF greater than HIIT ($p=0.115$). Generally, a similar decrease in the two parameters would be expected, as Despres et al. (15) and Despres et al. (16) found that abdominal fat and %BF decreased to a similar extent after an exercise treatment period. It is possible that the methods used to obtain the measurements allowed for some error. Hydrostatic weighing is considered a reliable method for determining body composition (23), however there is the possibility for error to occur. If the subjects did not do a maximal exhalation upon submersion then the results could be skewed. Additionally, the comfort level of the subjects being submerged underwater and motionless could have affected the results even though there was time allotted for learning and adjusting to the procedure. A lack of comfort was identified in a few subjects, mainly those in the HIIT group. Based on this information it is possible that the observed changes in waist circumference more accurately represent the effects of the two treatment groups.

It has been reported that a five to ten percent reduction in weight is beneficial in reducing the potential health risks typically associated with obesity (29, 64). The subjects in the present study did not meet the five to ten percent range, with weight losses being just under three percent. Unlike the studies by Tremblay et al. (64) and Kanaley et al. (29), this study did not analyze blood parameters associated with some of the obesity-related diseases. Because the subjects did experience some weight loss, it is likely that there were minor improvements in disease risks such as improved plasma triglycerides and cholesterol levels as well as increased glucose tolerance and insulin sensitivity. Subjects who continued to adhere to the diet and exercise behaviors adapted during the study may show more dramatic improvements in health over a longer period of time.

Another desired result of a weight loss program that may also affect disease risk is a decrease in waist circumference. The subjects in the present study boasted that they had to tighten their belts, and that their pants were looser in the waist than before participating in the study. Because an accumulation of fat in the abdominal region is associated with an increased risk of developing coronary heart disease and type 2 diabetes (49) it is important to identify ways in which abdominal fat can be reduced. Other studies have identified that exercise can decrease abdominal fat, for example, Despres et al. (16) demonstrated a significant reduction in abdominal fat in obese women after 14 months of moderate intensity aerobic training. Additionally, Tremblay et al. found through a survey that those individuals who reportedly engaged in high intensity activities had a reduced WHR, mainly due to a lower waist circumference (63). The present study as well as those of Despres et al. (16) and Tremblay et al. (63) provide evidence that diet combined with either MIT or HIIT can decrease the accumulation of abdominal fat and potentially decrease disease risk.

Enzyme analysis revealed increases in HADH activity in MIT and HIIT, with a trend for a greater increase in HIIT. This is not in agreement with the results obtained by Tremblay et al. (65) who found that HIIT significantly increased HADH activity 60%, whereas MIT did not. Phillips et al. (44) studied only MIT and found a significant 24% increase the activity of HADH. Additionally, MacDougall et al. (36) found that HIIT has the potential to increase the activity of HADH, although not to the extent of that reported by Tremblay et al. (65). Based on data from the present study and others, it appears that HADH may be more adaptable to HIIT than MIT. It is possible that the fuel use during exercise influences the adaptability of HADH to different exercise intensities.

HIIT has been shown to rely on three energy systems, CP, anaerobic glycolysis, and aerobic metabolism for the production of ATP (23, 46). Serresse et al. (55) examined three different maximal effort tests of 10, 30 and 90 seconds to determine energy contribution from the three systems. Results from the 10 second exercise bout revealed that 53% of the energy was derived from the CP system, 44% from anaerobic glycolysis, and 3% from aerobic metabolism. In the 30 second test, the energy contributions were 23%, 49%, and 28% for the CP system, anaerobic glycolysis, and aerobic metabolism, respectively. Lastly, during the 90 second bout, 12% of energy was from the CP system, 42% from anaerobic glycolysis, and 46% from aerobic metabolism. Closer inspection revealed that during the 90 second test, the maximal contribution of each energy system was during 0-15 seconds for the CP system, 16-30 seconds for anaerobic glycolysis, and 61-75 seconds for aerobic metabolism. Additionally, a study by Yamamoto and Kanehisa (70) demonstrated a similar finding in that aerobic metabolism is the main contributor of energy after 60 seconds of supramaximal cycling.

The duration of the high intensity intervals in the present study were 30, 90, and 180 seconds for the short, medium, and long intervals, respectively. This indicates that all three energy systems were utilized in each interval with an increased reliance on aerobic metabolism in the intervals greater than 60 seconds. Additionally, exercise at 40% VO_2max between the intervals likely relied heavily on aerobic metabolism for ATP production.

Kiens and Richter (30) found an increase in the oxidation of intramuscular triglycerides for 30 hours after an exhaustive exercise bout consisting of high intensity intervals. Additionally, Kiens and Richter reported that resynthesis of glycogen in the post-exercise period has a high metabolic priority resulting in intramuscular triglyceride stores being utilized for aerobic metabolism within the muscle (30). Although the HIIT exercise in this study was not

exhaustive, it is possible that there was a higher rate of fat oxidation in the post-exercise period due to replenishing of glycogen stores.

Recruitment of the various energy systems during and after exercise may have influenced the ability of HADH to potentially adapt to HIIT more so than MIT. Additionally, if the aerobic energy system is utilized extensively during and after HIIT this type of exercise may promote greater improvements in fat oxidation and possibly a decrease in body fat after a training period longer in duration than nine weeks.

A relationship between the rate of fat oxidation and changes in body fat has been looked at briefly. Calles-Escandon et al. (8) found that normal weight individuals who engaged in moderate intensity physical activity for 10 days had an increased amount of fat oxidation at rest. Interestingly, this increase in fat oxidation was not related to changes in body composition. Zurlo et al. (73) studied a combined group of normal weight and obese individuals and found that those with a higher activity of HADH also had a higher rate of fat to carbohydrate oxidation suggesting that those individuals are less likely to be in positive fat balance. Calles-Escandon et al. (8) monitored alterations in fat oxidation that occur as a result of exercise for only ten days. This may explain why they did not observe a decrease in body fat whereas, the present study of nine weeks demonstrated a decrease in body fat. Because the subjects in the present study demonstrated an increased HADH activity, they may also have a higher rate of fat to carbohydrate oxidation as described by Zurlo et al. (73), therefore explaining the observed decrease in body fat. Fat oxidation is a complex process and more research is necessary to understand the relationship between exercise intensity, fat oxidation, and body fat loss.

The present study provided some valuable information about diet and exercise treatment in an obese population. First, obese individuals were able to tolerate both MIT and HIIT.

Secondly, this study confirmed that a diet and exercise program can promote decreases in body weight, body fat, and waist circumference. Because there were no differences observed between the two exercise treatments it is recommended that obese individuals be advised to take part in any type of exercise as part of their weight loss efforts. It is possible that in the future HIIT may be more beneficial, but until then, an increase in physical activity will produce favorable results when adhered to.

RECOMMENDATIONS FOR FUTURE RESEARCH

1. When compared to other exercise training studies (7, 16, 22, 64) the treatment intervention was short. It is possible that increasing the training period to at least 12 weeks or longer in duration would provide a greater difference or demonstrate a greater similarity between the two protocols.
2. The workload may have more accurately represented the subjects' improving fitness if $VO_2\text{max}$ was measured several times during the study and the workload adjusted accordingly.
3. This study was done on overweight/obese male subjects, Tremblay et al. (65) studied healthy males and females, but did not provide data for males or females separately, and MacDougall et al. (36) studied fit males performing repeated intervals. A group consisting solely of females performing HIIT has not been looked at; therefore it is recommended that overweight/obese females be studied to determine the effects of HIIT.
4. With increasing numbers of overweight/obese children, it is important to identify which activities are most beneficial for children to take part in. The value of HIIT could be tested in this population.

5. The subjects in the present study were instructed on the diet to follow during week two. It would be better if the diet instruction took place prior to beginning the exercise training. This would allow for both components to start simultaneously.
6. A controlled feeding study would allow for better control over the subject's energy intake.
7. MIT as part of a weight loss program has aided in improving glucose tolerance and insulin resistance as well as lowering plasma triglyceride and cholesterol levels. Identifying changes that occur in these parameters with HIIT training would be beneficial in determining which exercise training elicits better improvements in health status.
8. Acute studies with indirect calorimetry identified that MIT oxidizes more fat than HIT during exercise (62), and that HIT oxidizes more fat in the post exercise period (43). Measuring the effects of MIT versus HIIT on fuel oxidation would be of equal interest before and after a training period instead of an acute exercise regime. Additionally, use of infused-labeled fatty acids would allow more accurate identification of fat oxidation during and after MIT and HIIT.