

UNIVERSITY OF WISCONSIN-LA CROSSE

Graduate Studies

RELATIVE INTENSITY AND ENERGY EXPENDITURE OF A TABATA  
WORKOUT

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the  
Degree of Master of Science, Clinical Exercise Physiology

Talisa M. Emberts

College of Exercise and Sport Science  
Clinical Exercise Physiology

May, 2013

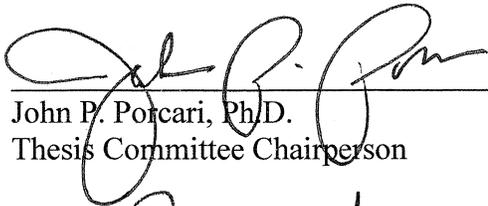
RELATIVE INTENSITY AND ENERGY EXPENDITURE OF A TABATA

WORKOUT

By Talisa M. Emberts

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree Master of Science, Clinical Exercise Physiology.

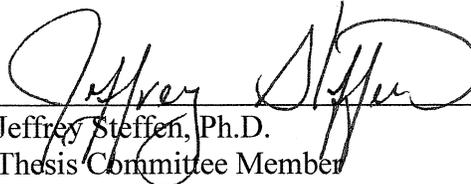
The candidate has completed the oral defense of the thesis.

  
\_\_\_\_\_  
John P. Porcari, Ph.D.  
Thesis Committee Chairperson

5/6/13  
Date

  
\_\_\_\_\_  
Scott Döberstein, M.S.  
Thesis Committee Member

5/6/13  
Date

  
\_\_\_\_\_  
Jeffrey Steffen, Ph.D.  
Thesis Committee Member

5/6/13  
Date

Thesis accepted

  
\_\_\_\_\_  
Steven Simpson, Ph.D.  
Graduate Studies Director

5/28/13  
Date

## ABSTRACT

Emberts, M.E. Relative intensity and energy expenditure of a Tabata workout. MS in Clinical Exercise Physiology, May 2013, 46pp. (J. Porcari)

This study was designed to examine the relative intensity and energy expenditure of a Tabata workout in relation to ACSM guidelines. Sixteen subjects (8 males, 8 females) performed a  $VO_2$ max test to determine HRmax and  $VO_2$ max. An individual HR- $VO_2$  regression equation was established for each subject based upon the treadmill test. After treadmill testing, subjects completed two identical 20-minute Tabata workouts. HR responses during each minute of Tabata were used to estimate  $VO_2$  and caloric expenditure. HR responses during Tabata averaged 86% of HRmax. Estimated  $VO_2$  during the Tabata workout averaged 74% of  $VO_2$ max. Estimated caloric expenditure averaged 15 kcal/min (240-360 kcal/workout). Thus, it was concluded that Tabata training meets ACSM guidelines for exercise intensity and caloric expenditure during an exercise session. This finding solidifies the notion that Tabata may be another option for individuals looking for a quick, yet effective workout.

## ACKNOWLEDGEMENT

It is with great pride that I acknowledge several people for their support and guidance through the development of this thesis and their support through this entire graduate program.

I would like to thank my committee chair Dr. John Porcari for advising me through the thesis process, without your guidance this would not have been possible.

Additionally, I would like to thank Scott Doberstein and Jeffery Steffen for all of their suggestions as well as serving on my thesis committee.

Next, I would like to thank my family, friends, and classmates for their help, support, and encouragement throughout this program and for always being there for me. I do not know where I would be today without all of you.

Finally, I would like to thank my subjects for their patience and dedication through the data collection process. I couldn't have asked for a harder working group of individuals to work with.

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## INTRODUCTION

Traditionally, the recommendation has been made that individuals should exercise for a minimum of 30 minutes, 5 days per week, in order to obtain the health and fitness benefits of exercise. (American College of Sports Medicine, 2010; Haskell et al., 2007). The problem with this recommendation is that lack of time is listed as one of the most common barriers to exercise in a variety of populations. (Godin et al., 1994) As a result, exercise programs that have demonstrated health and fitness benefits, with minimal time commitments, have become increasingly popular. One of the earliest examples of this type of training is the “Tabata” method. The Tabata method consists of short bouts (20 seconds) of high intensity exercise interspersed with short (10 second) rest periods. Evidence suggests that Tabata training is effective for inducing physiological benefits (Tabata et al., 1996).

Tabata training was first developed by the Japanese scientist Izumi Tabata in 1996. Tabata and his colleagues (1996) conducted a study which compared moderate intensity continuous training at 70% of maximal oxygen consumption ( $VO_2\text{max}$ ) for 60 minutes, with high intensity interval training (HIIT) at 170% of  $VO_2\text{max}$ . HIIT consisted of 8, 20-second all-out exercise bouts followed by 10 seconds of rest for a total of 4 minutes of exercise. The results of the study found that HIIT improved aerobic capacity to a greater degree than moderate continuous training (7 ml/kg/min versus 5 ml/kg/min). Additionally, HIIT produced an increase of 28% in anaerobic capacity, which aerobic training failed to do

Tabata's findings led to the development of a wide variety of HIIT programs. Although there are many different ways to perform HIIT, all of the programs are characterized by periods of all-out effort combined with periods of complete rest or low to moderate recovery periods (Gibala & McGee, 2008). Common findings have been that HIIT induces an increase in  $VO_2$ max (Bayati, Farzad, Gharakhanlou, Agha-Alinejad., 2011; Guiraud et al., 2010; Helgerud et al., 2007; Rognmo, Hetland, Helgerud, Hoff, Slordahl., 2004; Whyte, Gill, Cathcart., 2010). This is important because  $VO_2$  max is a common and effective measurement of overall fitness level. It has also been found that HIIT improves insulin sensitivity (Babraj et al., 2009; Nybo et al., 2010; Whyte et al., 2010), HDL levels (Tjonna et al., 2009), and blood pressure (Gibala & McGee, 2008; Whyte et al., 2010), while decreasing percent body fat (Trembley, Simoneau, Bouchard., 1994). Additionally, HIIT not only provides benefits for trained individuals (Burgomaster, Hughes, Heigenhauser, Bradwell, Gibala., 2005), but has been shown to improve health and fitness parameters in sedentary (Babraj et al., 2009), overweight/obese (Nybo et al., 2010; Whyte et al., 2010), and cardiac populations (Guiraud et al., 2009; Rognmo et al., 2004; Whyte et al., 2010).

Today many Americans look for the easy way out or the short cut to weight loss. Research has shown that HIIT burns fat more quickly than continuous endurance training (Burgomaster et al., 2005). In addition to lack of time, adherence is also a common concern when prescribing exercise. A study by Hegerud et al. (2007) suggests that people are more likely to adhere to HIIT than moderate endurance training. Therefore, using the Tabata method may be a powerful workout tool.

Based on previous research, HIIT has been shown to improve aerobic and anaerobic capacity and may favor other health and fitness benefits. However, there is limited research regarding the relative exercise intensity and energy expenditure of Tabata training. Therefore, the purpose of the present study was to determine the relative exercise intensity and energy expenditure of a typical Tabata workout.

## **METHODS**

### **Subjects**

Subjects were 16 moderately to highly trained volunteers between 20-47 years of age. All subjects were required to complete a PAR-Q questionnaire prior to enrolling in the study to screen for any major health problems that would preclude HIIT training. Approval from the Institution Review Board for the Protection of Human Subjects at the University of Wisconsin La Crosse was obtained in advance of testing. In addition, each subject provided written informed consent beforehand.

### **Testing Procedures**

Initially, each subject performed a maximal exercise test on a treadmill to determine  $\text{VO}_2\text{max}$  and maximal heart rate (HR). The test began with a short warm-up, followed by walking or running at a self-selected speed. Treadmill grade began at 0% and increased 2.5% every two minutes until the subject reached volitional exhaustion. Expired gases were measured using open circuit spirometry (AEI, Pittsburgh, PA). Ratings of perceived exertion (RPE) and HR were recorded every two minutes utilizing the 6-20 Borg scale and a radio telemetric HR monitor (Polar Electro Oy, Plymouth, NY), respectively (Borg, 1973). Individual HR/ $\text{VO}_2$  regression equations were developed for each subject utilizing the HR and  $\text{VO}_2$  responses during the last 30 seconds of each stage of the incremental treadmill test. These individual HR/ $\text{VO}_2$  regressions were later used to predict  $\text{VO}_2$  and caloric expenditure responses during Tabata training.

## Testing Protocol

Prior to being tested, subjects practiced each Tabata routine, until the principle investigator deemed them proficient at performing all of the exercises. Each workout consisted of four “rounds” of exercise. The exercises performed during each round are presented in Table 1. Subjects completed the same workout twice with a minimum of 48 hours between sessions.

Table 1. Exercises included in the 20-minute Tabata workout

	Minute 1	Minute 2	Minute 3	Minute 4
Segment 1	High Knee Run	Plank Punch	Jumping Jacks	Side Skaters
Segment 2	Jump Rope	In/Out Boat	Line Jumps	Push-Ups
Segment 3	Burpees	Russian Twists	Squats	Lunges
Segment 4	Mt. Climbers	Push-Ups	Split Squat	Box Jumps

Each testing session began with a 5-minute warm-up. Subjects then completed four rounds of Tabata for a total of 20 minutes of exercise. Each round of Tabata included performing exercise at a ratio of 20s:10s. This ratio refers to 20-seconds of high intensity exercise followed by 10 seconds of recovery for a total of eight repetitions. During the 20-second exercise phase, the subject performed as many repetitions of each exercise possible. The rest segment included getting the equipment for, or moving to, the next station. Every session ended with a 10-minute cool-down.

For all testing, HR was measured every minute using a Polar monitor (Polar Electro Oy, Plymouth, NY). Blood lactate concentration was obtained at the completion of each 4-minute Tabata round using a finger prick blood sample. Blood lactate was

determined using a Nova Biomedical Lactate Plus blood lactate analyzer (Waltham, MA). Ratings of perceived exertion (RPE) were determined using the 6-20 Borg scale at the completion of each 4-minute Tabata round (Borg, 1973).

Predicted  $\text{VO}_2$  during exercise was calculated using the individual's HR/ $\text{VO}_2$  regression equation developed from the maximal exercise test. HRs obtained during testing were inserted into the equation to determine predicted  $\text{VO}_2$  during each minute of exercise. Energy expenditure (kcal) was determined using the  $\text{VO}_2$  data assuming a constant of 5 kcal/L of  $\text{O}_2$  consumed.

### **Statistical Analysis**

Statistical analysis included standard descriptive statistics to characterize the subject population as well as to determine exercise intensity and energy expenditure of participation in the Tabata workout. Differences between gender and Tabata sessions were assessed using two-way ANOVA with repeated measures. Alpha was set at  $p < 0.05$  to achieve statistical significance for all analyses. All analyses were conducted using the Statistical Package for the Social Sciences (SPSS, Version 19; SPSS Inc., Chicago, IL.)

## RESULTS

Sixteen moderately fit men (8) and women (8) between 20-47 years of age completed the preliminary VO<sub>2</sub>max test as well as two, 20-minute Tabata workouts. Descriptive characteristics of the subjects are presented in Table 2. The males in the study were significantly older, taller, heavier, and had a higher VO<sub>2</sub>max than the female subjects.

Table 2. Descriptive characteristics of the subjects.

	Female (n=8) Mean ± SD	Male (n=8) Mean ± SD
Age (years)	28.4 ± 9.27	35.3 ± 8.10*
Height (cm)	170.5 ± 8.63	181.3 ± 6.06*
Weight (kgs)	71.9 ± 11.97	93.7 ± 8.70*
HR <sub>max</sub> (bpm)	183 ± 10.9	179 ± 12.3
VO <sub>2</sub> max (ml/kg/min)	42.9 ± 11.27	53.2 ± 9.64*

\*Significantly different than females (p<.05).

The average exercise responses to the two Tabata workouts are presented in Table 3. There were no significant differences in the HR, RPE, lactate, estimated VO<sub>2</sub>, responses between men and women or between the two Tabata workouts. There was a significant difference in energy expenditure between men and women for both Tabata

workouts, with men burning more calories than women due to differences in body weight.

Table 3. Exercise responses for the two Tabata workouts.

	Tabata Workout 1 Mean $\pm$ SD	Tabata Workout 2 Mean $\pm$ SD
Heart Rate (bpm)		
Females	161 $\pm$ 10.3	158 $\pm$ 13.5
Males	151 $\pm$ 13.7	155 $\pm$ 15.2
% HR		
Females	88 $\pm$ 5.7	86 $\pm$ 7.4
Males	84 $\pm$ 4.7	87 $\pm$ 7.6
VO <sub>2</sub> (ml/kg/min)		
Females	33.7 $\pm$ 5.28	31.5 $\pm$ 6.35
Males	35.4 $\pm$ 6.39	38.7 $\pm$ 7.19
% VO <sub>2</sub>		
Females	81 $\pm$ 11.4	76 $\pm$ 15.0
Males	67 $\pm$ 8.6	73 $\pm$ 12.1
Kcals/min		
Females	12.0 $\pm$ 2.23	11.3 $\pm$ 2.68
Males	16.5 $\pm$ 2.65*	18.1 $\pm$ 3.41*
Session RPE		
Females	15.1 $\pm$ 0.99	14.5 $\pm$ 1.41
Males	15.6 $\pm$ 1.41	15.7 $\pm$ 1.49
$\Delta$ Lactate		
Females	11.1 $\pm$ 2.64	11.0 $\pm$ 3.12
Males	11.3 $\pm$ 1.69	13.3 $\pm$ 1.50

\*Significantly different from females (p<.05)

HR,  $VO_2$ , RPE, and lactate responses for each segment of both Tabata workouts are graphically presented in Figure 1-4, respectively. It can be seen that for all variables, responses went up in a stepwise fashion with each successive segment.

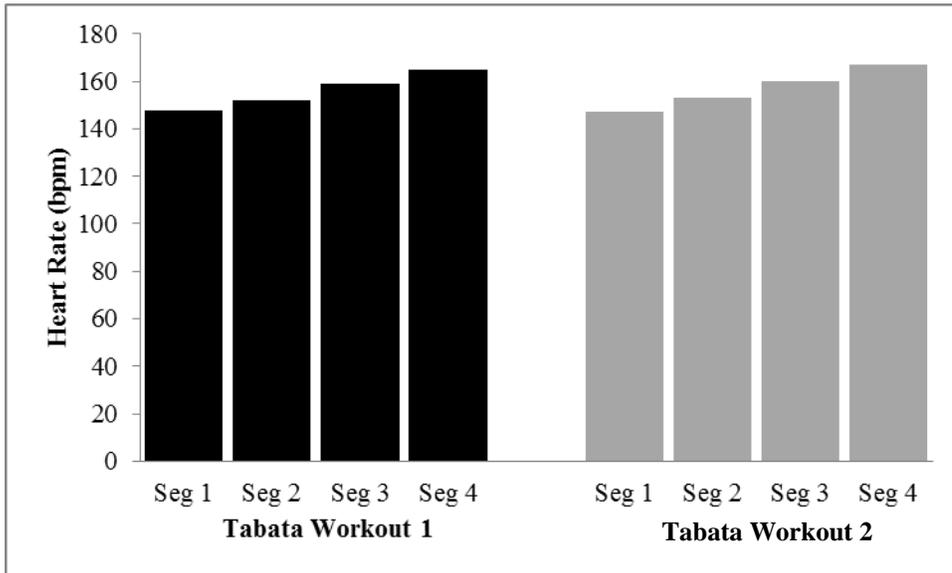


Figure 1. Average heart rates for each 4-minute Tabata segment.

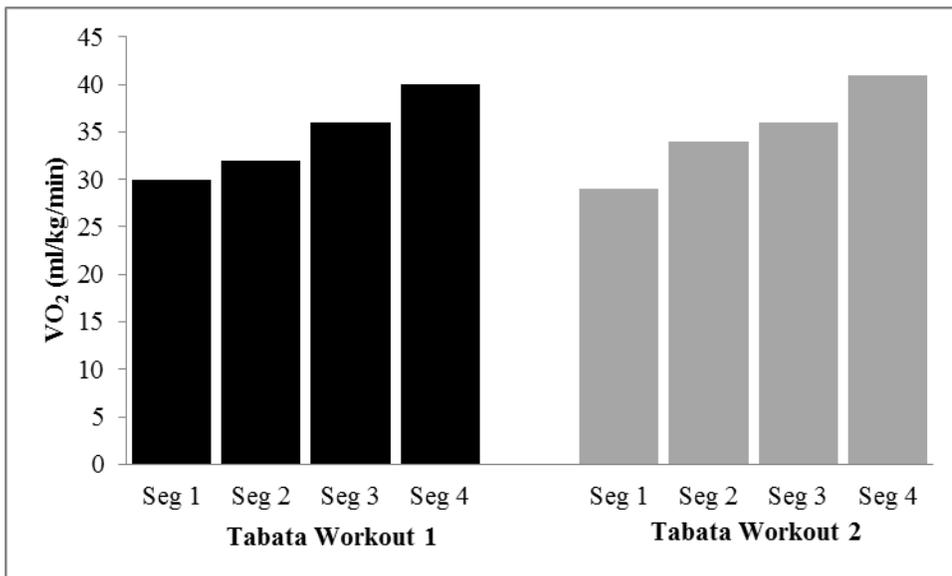


Figure 2. Average estimated  $VO_2$  for each 4-minute Tabata segment.

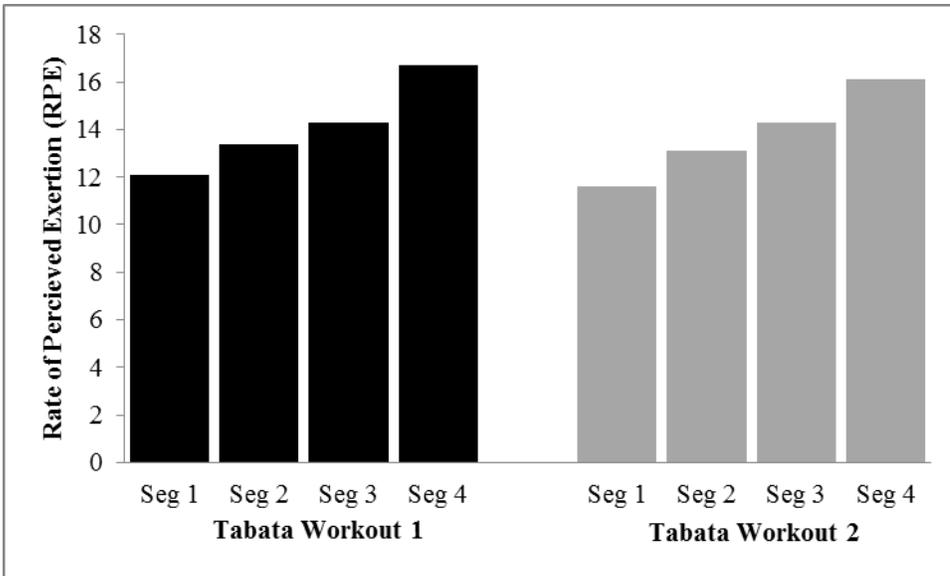


Figure 3. Average RPE for each 4-minute Tabata segment.

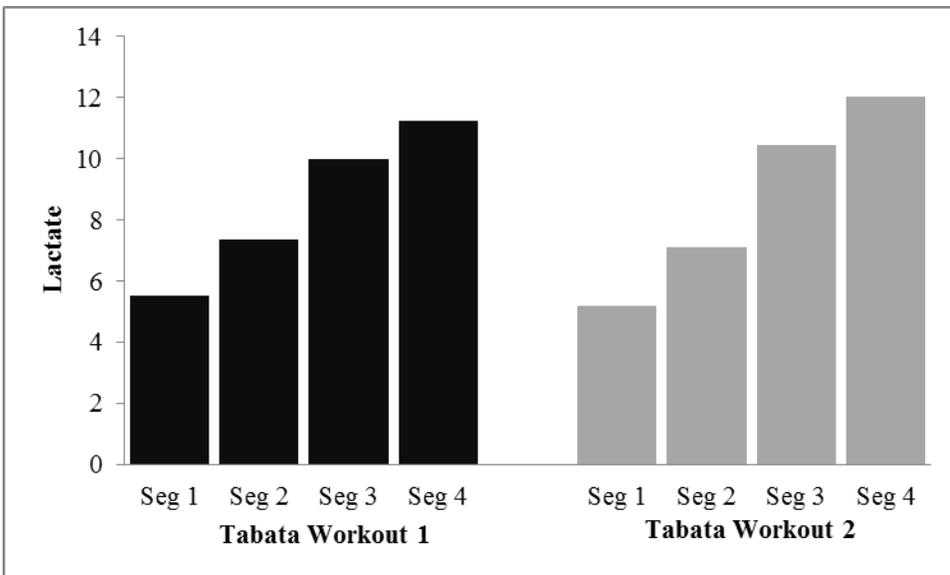


Figure 4. Average lactate responses between each 4-minute Tabata segment. (Values represent the difference in lactate from resting values)

## DISCUSSION

The purpose of this study was to determine the relative exercise intensity and caloric expenditure of a Tabata workout, and to compare these values to American College of Sports Medicine (ACSM, 2010) guidelines for improving cardiorespiratory endurance and modifying body composition. ACSM (2010) recommends that individuals exercise between 64-94% of HRmax or 40-85% of VO<sub>2</sub>max in order to improve their aerobic fitness. In the current study, exercise intensity averaged 86% of HRmax (range of 84-88%) and 74% of VO<sub>2</sub>max (range of 67-81%) for the two Tabata workouts. Thus, Tabata meets these guidelines for exercise intensity.

In terms of energy expenditure, ACSM (2010) recommends that individuals accumulate a minimum of 1,000 kcal of physical activity per week (150-300 kcal per session) in order to improve their health. A weekly energy expenditure of 2,000 kcal, or greater, is recommended for enhanced weight loss. The 16 subjects expended between 240-360 kcals during the workout, an average of 15 kcals/min. Therefore, Tabata appears to be an effective workout technique for improving cardiorespiratory fitness, as well as providing weight loss benefits in a short period of time.

The average RPE for the two Tabata workouts was 15.4, indicating that the workouts were rated as “hard” by the subjects. As further evidence of the vigorous intensity of Tabata, blood lactate was measured during each workout. Lactate concentrations averaged 12.1 mmol/l after the 20-minute Tabata sessions, which indicates

that subjects were working well above their lactate threshold. A blood lactate concentration of 4mmol/l is considered above the second threshold (Foster & Cotter, 2005)

The original study on what is now known as “Tabata” training was conducted by Izumi Tabata (1996). He had subjects cycle at 170%  $VO_2$ max in increments of 20 seconds work, 10 seconds rest for 4 minutes. In 6 weeks, subjects had a 14% increase in  $VO_2$ max and a 28% increase in anaerobic capacity. A steady state exercise group, which exercised for 60 minutes per day, only had a 10% increase in  $VO_2$ max and no improvement in anaerobic capacity. Although this original form of Tabata increased both aerobic and anaerobic capacity, 4 minutes of exercise would not result in sufficient energy expenditure to decrease body weight significantly. In the current study, in order to make the Tabata method more beneficial, four, 4-minute bouts of Tabata were stacked, with 1 minute of rest between bouts. This resulted in a longer workout, which burned a greater number of calories, while also incorporating different exercises for a total body workout.

Other studies that have utilized HIIT have also found an increase in  $VO_2$ max superior to those seen following steady-state exercise. Nybo et al. (2010) studied the training responses of four different training protocols. These included intense interval training (INT), prolonged running, strength training, and a no exercise control condition. It was found that the INT group was superior to prolonged running and strength training in increasing  $VO_2$ max. Another study done by Helgerud et al. (2007) found that 15 15-second and 4 3-minute intervals at 90-95%:70% increased  $VO_2$ max more significantly than training long and slow (70% HRmax for 45 minutes).

Other high intensity training protocols found results similar to the current study. Energy expenditure and relative exercise intensity during boot camp training were examined by Porcari, Hendrickson, and Foster (2008). Twelve men and women participated in the study and were asked to follow along with a 40-minute boot-camp exercise video. Results showed that subjects exercised within ACSM (2010) guidelines, working at an intensity of 77% of HRmax and 62% of VO<sub>2</sub>max. Energy expenditure was also above ACSM minimum guidelines, averaging 9.8 kcal/min (392 kcals/workout). A more recent study completed by Woldt, Porcari, Doberstein, Steffen, and Foster (2011) examined the physiological responses to four P90X workouts. Intensity across the four workouts ranged from 65-88% of HRmax and 45-80% of VO<sub>2</sub>max. Energy expenditure ranged from 7.2-16.2 kcals/min and subjects expended between 302-699 kcals per workout. Again, these results indicate that P90X exceeds ACSM guidelines for improving cardiorespiratory endurance and improving body composition.

Limitations of this study include the inability to directly measure VO<sub>2</sub> during the 20-minute Tabata workout. It was felt that wearing the portable metabolic equipment would inhibit the subjects from effectively performing Tabata, which may have affected exercise intensity. Another limitation was the variation in participant skill levels. Subjects were required to demonstrate efficiency with each Tabata exercise prior to testing. However, even after practice, some subjects were more skilled than others, which could have affected HR responses during exercise. Furthermore, some subjects had more overall experience with these agility and high intensity type exercises than others.

The results of this study indicate a 20-minute Tabata session using body weight exercises combined with plyometrics meets ACSM guidelines for exercise intensity and

caloric expenditure, and thus may be another option for individuals looking for an effective, yet quick, workout. Future studies may want to determine the physiological benefits after a prolonged period of Tabata training.

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APPENDIX A

PAR-Q

# 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	
<input type="checkbox"/>	<input type="checkbox"/>	1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
<input type="checkbox"/>	<input type="checkbox"/>	2. Do you feel pain in your chest when you do physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	3. In the past month, have you had chest pain when you were not doing physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
<input type="checkbox"/>	<input type="checkbox"/>	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?
<input type="checkbox"/>	<input type="checkbox"/>	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
<input type="checkbox"/>	<input type="checkbox"/>	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.**



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continued on other side...

APPENDIX B  
INFORMED CONSENT

## **INFORMED CONSENT**

### **Determining the Relative Intensity and Energy Expenditure of a Tabata Workout**

I, \_\_\_\_\_, volunteer to participate in a research study being conducted at the University of Wisconsin-La Crosse.

#### **Purpose and Procedures**

- The purpose of this study is to evaluate the intensity of Tabata training and to determine how many calories are expended during those workouts.
- A Tabata round consists of short bouts (20 seconds) of high intensity exercise interspersed with short (10 second) rest periods for a total of 4 minutes. A Tabata testing session will consist of four, 4 minute rounds.
- Prior to testing, I will practice each exercise to be used during the Tabata workouts until the lead investigator deems that I am proficient.
- My participation in this study will consist of three separate sessions.
- The first session will be a maximal exercise test on a treadmill. The test will start out at a low level and progressively increase until I can no longer continue. During the maximal treadmill test I will wear a chest strap to measure my heart rate and a scuba like mask to collect expired air.
- The next two sessions will be Tabata workouts. During these I will wear the chest strap to measure my heart rate and rate my perceived exertion. A sampling of my blood will also be taken using a finger prick three times to help determine my blood lactate.
- Total time requirement will be between 3-4 hours.
- Testing will take place in Mitchell Hall on the UW-L campus.
- Research assistants will be conducting the research under the direction of Dr. John Porcari, a professor in the department of Exercise and Sport Science.

#### **Potential Risks**

- I may experience substantial overall muscle fatigue, shortness of breath, and muscle soreness as a result of the workouts used in the current study.
- Pulled muscles and other minor injuries may occur as with any other high intensity workout.
- The risk of serious or life-threatening complication is very low (<1/10,000 tests) in apparently healthy, regularly exercising adults.
- The rest will be stopped immediately upon the development of any complications.
- There will be persons trained in CPR and Advanced Cardiac Life Support available for every testing session.

**Benefits of Participation**

- By volunteering in this study, I will gain a better understanding of my physical fitness level.
- This study will also be important for exercise professionals, researchers, and the general public who are interested in the effectiveness of Tabata training for improving cardiorespiratory fitness or controlling body weight.
- I will receive \$10 if I complete all testing in this study.

**Rights and Confidentiality**

- My participation is voluntary.
- I may choose to discontinue my involvement in this study at any time without penalty.
- The results of this study have the potential of being published or presented at professional meetings, but only group data will be presented.

I have read the information provided on this consent form. I have been informed of the purpose of this study, the procedures, and the expectation of myself as well as the testers, and of the potential risks and benefits that may be associated with volunteering for this study. I have asked any and all questions that concerned me and received clear answers so as to fully understand all aspects of this study.

Concerns about any aspects of this study may be directed to Talisa Emberts (262-510-4771), the principal investigator, or her advisor Dr. Porcari at (608-785-8684). Questions about the protection of human subjects may be addressed to Dr. Bart Vanvoorhis (608 785 6892), Chair of the UW-L Institutional Review Board for the protection of human subjects.

Participant’s Name: \_\_\_\_\_

Participant’s Signature: \_\_\_\_\_ Date: \_\_\_\_\_

Researcher’s Signature: \_\_\_\_\_ Date: \_\_\_\_\_

APPENDIX C  
REVIEW OF LITERATURE

## REVIEW OF LITERATURE

Different exercise routines have been developed over the years to attempt to make effective exercise both worthwhile and enjoyable. Traditionally, American College of Sports Medicine (ACSM) recommends that people perform 30 minutes of moderate intensity endurance training 5 days a week in order to positively impact their health (ACSM, 2010). The problem with this recommendation is that lack of time is one of the most common barriers to exercise in a variety of populations (Godin et al., 1994). Therefore, exercise prescriptions that have demonstrable health and fitness benefits while minimizing the time commitment have become increasingly popular. One variety of this brief type of training is the “Tabata” method. Tabata is a combination of high intensity interval training and circuit resistance training. It consists of eight rounds of 20 seconds all-out exercise bouts followed by 10 seconds of rest for a total of 4 minutes. Both HIIT and circuit resistance training have shown to improve health and fitness components. Consequently, it is believed that the combination of the two forms of exercise would be effective and time efficient. The problem is that although Tabata is appealing to the general population, no research has been done to determine the validity of its workouts relative to the energy expenditure and cardiorespiratory fitness guidelines recommended by the American College of Sports Medicine (ACSM, 2010). Hence, this review was conducted to reflect upon existing literature of similar workouts to Tabata, including the effects on energy expenditure and cardiorespiratory fitness. In the following review of literature we will examine the current exercise recommendations and benefits, HIIT,

circuit training, caloric expenditure during other modes of exercise, and information presented on the Tabata website itself.

### **Exercise Recommendations and Benefits**

The ACSM (2010) provides general principles of exercise prescription for all types of populations. They include frequency, intensity, time, and type as well as appropriate energy expenditure levels. ACSM addresses both cardiovascular endurance and resistance training, since both components are essential to an individual's health and fitness. When focusing on cardiovascular endurance, ACSM recommends that accumulating a minimum of 1,000 kcal of physical activity a week or 150-300 kcal per session results in improved health, specifically improvement in cardiovascular and respiratory function. To achieve this level of energy expenditure, individuals must accumulate the equivalent of 150 minutes of moderate intensity activity a week at an intensity of at least 64-94% of heart rate (HR)<sub>max</sub> or 40-85% of maximal oxygen consumption (VO<sub>2</sub>)<sub>max</sub>. A weekly energy expenditure of 2,000 kcal or greater is needed for enhanced weight loss. This level of energy expenditure could be achieved in 250-300 minutes a week or 50-60 minutes a day. In addition to cardiovascular health, resistance training is also recommended by ACSM. They recommend that resistance training should be performed 2-3 days a week, separated by at least 48 hours, and should focus on all of the major muscle groups. Resistance training intensity should be conducted at 50-80% of 1-RM.

### **High Intensity Interval Training**

**Effect of HIT on VO<sub>2</sub> Max, Aerobic and Anaerobic Capacity.** VO<sub>2</sub> max is arguably the most impacting factor in determining a person's overall fitness level. This is

commonly known as the maximum capacity of the body to transport and utilize oxygen for the use of energy. It is measured with an incremental exercise test, working until the point of volitional exhaustion. (Behm & Adams, 2011).

Many studies have been completed on high intensity interval training (HIIT). Tabata and colleagues were interested in comparing the effects of moderate intensity endurance training and HIIT on anaerobic capacity and VO<sub>2</sub>max (aerobic capacity). Two groups were trained over a 6-week period, with one group performing 60 minutes, 5 days a week, at a continuous intensity of 70% VO<sub>2</sub>max. The other group participated in interval exercise (7-8 sets of 20s exercise, 10s rest) four times a week at 170% of VO<sub>2</sub>max. Results indicated that both groups had an increase in their VO<sub>2</sub>max but the interval training group had a greater increase (14% vs.10%), as well as had a 28% increase in their anaerobic capacity, while the endurance training group had little to no change (Tabata et al., 1996).

Several other studies had the same focus as Tabata and utilized 2-6 week training durations. Training included 4-7 intervals of 30-second all-out sprints on either a treadmill or cycle ergometer followed by 4-4.5 minutes of recovery. Each study showed significant improvement in VO<sub>2</sub>max with interval training group (Burgomaster, Hughes, Heigenhauser, Bradwell, and Gibala., 2005; Macpherson, Hazell, Olver, Paterson, and Lemon., 2011; Whyte, Gill, and Cathcart., 2010). Additionally, these studies showed improvements in % body fat, time trial performance, and blood pressure in both healthy (Burgomaster et al., 2005; Macpherson et al., 2011) and overweight individuals (Tjonna et al., 2009; Whyte et al., 2010). A study done by Gibala and McGee (2008) supported

the above findings and found that results could be attained with only six sessions of HIIT over two weeks, totaling 15 minutes of exercise.

Moreover, longer study periods using HIIT have also been used. A study done by Little, Safdar, Wilkin, Tarnopolsky, and Gibala (2010) explains that 8-12, 60-second intervals at peak power output rather than all-out exercise bouts elicit increases in skeletal muscle mitochondrial capacity and increases in time trial performance. This is important because it shows that interval exercise at a moderate level brings both a safe and effective alternative for those who are unable to work at their maximum. It could also be used as a means to progress toward the more intense workout regime. Another study done by Helgerud et al. (2007) found that 15 15-second and 4 3-minute intervals at 90-95%:70% respectively increased  $VO_2\text{max}$  more significantly than training long and slow (70%  $HR\text{max}$  for 45 minutes). Finally, Nybo et al. (2010) studied the training responses of four different training protocols. These included intense interval training (INT), prolonged running, strength training, and a no exercise control condition. It was found that the INT group was superior in increasing  $VO_2\text{max}$ .

**Effect of HIIT on Insulin.** It is well known that aerobic exercise helps to control insulin and glucose levels, but little is known about the effect interval training has on these factors. In young sedentary men, it was found that insulin action was improved with as little as 2 weeks of HIIT (15 minutes of total exercise). Subjects performed 6 sessions, 6 X 30s cycle sprints per session with 4 minutes of active recovery. (Babraj et al., 2005) Likewise, a 4-week study done by Bayati, Farzad, Gharakhanlou, Agha-Alinejad (2011) found that cycling 6-10 X 30s sprints at 125%  $VO_2$  peak with 2 minutes of recovery demonstrated the same results as 3-5 X 30s all-out sprints with 4 minutes of

recovery. This may signify that lowering the intensity and doubling the duration may provide the same benefits for improving insulin action in addition to other health benefits.

**Effect of HIIT on Overweight/Obese.** Interval training has also proven health and fitness benefits in the overweight/obese population although many may believe that this type of training may be too intense for an obese person. A study done by Tjonna et al. (2009) found that overweight/obese individuals were able to perform 4 x 4 minute intervals twice a week, at 90% of HRmax, separated by 3 minutes of active recovery at 70% of HRmax. After doing this for 3 months, there was noticeable increase in VO<sub>2</sub>max, enhanced endothelial function, reduced BMI, reduced percent of body fat, and enhanced peak oxygen pulse.

**Benefits of HIIT for Cardiac Patients.** The cardiac population is not being overlooked when it comes to integration of HIIT programs. There have been multiple studies performed regarding the effects of interval training on patients with heart conditions. Generally, cardiac patients have a lower exercise capacity due to poor function of the heart (cardiac output). Traditionally, steady state exercise has been successful in inducing positive changes in exercise capacity, therefore it is highly recommended for cardiac patients.

Although the perfect exercise prescription for cardiac patients is not known, various studies have found HIIT to be more beneficial than lower intensity endurance training. For that reason, there is a growing appreciation for the use of high-intensity training in persons with disease. Rognmo, Hetland, Helgerud, Hoff, and Slordahl (2004) studied coronary artery disease patients and compared both moderate intensity and high intensity exercise on a treadmill. The moderate intensity group trained at 50-60% of their

VO<sub>2</sub>peak for 41 minutes while the high intensity group trained at 80-90% VO<sub>2</sub>peak, doing 4 intervals of 4 minutes followed by 3 minutes of walking recovery. Both workouts maintained an equal training load and results showed that the high intensity training group more than doubled VO<sub>2</sub> in comparison to moderate intensity training.

Another study looked at heart failure patients to determine the effects of HIIT. Patients underwent a 2-week program, performing 4x4 minute intervals at 90-95% of HR peak with 3 minutes of active recovery for a total of 38 minutes. The opposing group did continuous walking at 70-75% of HRpeak for a total of 47 minutes. The study found that the high intensity training group was superior to the moderate intensity group with reversing left ventricle remodeling, aerobic capacity, endothelial function, and quality of life. Additionally, the studies participants were  $75.5 \pm 11.1$  in age, which is significant because generally the risk of heart failure increases with age and most studies eliminate the older population for safety concerns (Wisloff et al., 2007).

Guiradud et al. (2010) was not pleased with the current research that had been done and wanted to take HIIT research with cardiac patients one step further. Therefore, he organized subjects into four training groups which all exercised at 100% of maximal aerobic power. Groups included 15:15s exercise to passive recovery, 15:15s exercise to active recovery, 60:60s exercise to passive recovery, and 60:60s active recovery. The goal of the study was to determine which type of high intensity exercise would allow patients to be close to their VO<sub>2</sub>max and obtain a longer duration to exhaustion. It was found that the 15:15s, passive recovery group obtained the highest increase in VO<sub>2</sub> while still maintaining comfort, adherence, and safety.

## **Circuit Training**

Circuit weight training (CWT) has been studied over the years and has shown both health and fitness benefits. CWT is known as continuous weight training over a certain period of time with little or no rest between repetitions. To try and determine the level of cardiac stress presented by prolonged and continuous CWT, subjects performed 10 lifts at 40% of 1 repetition max (1-RM). The subjects performed the circuit of 10 lifts 4.6 times (4 times, plus another 6 exercises) in a row with 2-5 seconds rest between sets. Gotshalk, Berger, and Kraemer (2004) provided evidence from this study that CWT is able to elicit a HR between 70-80% of maximum as well as maintain a  $VO_2$  of approximately 50%  $VO_{2max}$ . These results meet ACSM's guidelines for improving cardiorespiratory fitness (ACSM, 2010). Furthermore, when comparing  $VO_2$  during treadmill running and CWT,  $VO_2$  was higher during treadmill running due to the use of larger muscle groups, but HRs were higher in CWT (Gotshalk et al., 2004).

Similar results were shown by Gettman, Ward, and Hagen (1982), who studied 41 males, 3 days a week over 12 weeks. Participants were broken up into two groups; CWT group and a CWT plus run group. The resistance training consisted of three circuits that included 10 exercises at 40% 1-RM for 12-15 repetitions. Both groups completed the resistance circuit, but the plus run group had 30 seconds of running between each training station. Results showed that both the CWT and the running and CWT combination had similar improvements in  $VO_{2max}$ , strength, and body fat.

Other studies done by Taskin (2009) and Harris and Holly (1987) have found improvements in agility performance, anaerobic endurance, lean body mass, and diastolic

blood pressure with CWT. The study done by Taskin et al. (2009) used 32 healthy males, whereas the Harris et al. (1987) focused on hypertensive males.

Finally, Gettman and Pollock (1981) looked at CWT to determine if it could improve or maintain  $VO_2$  as well as elicit energy expenditures that correlate with weight loss. It was found that CWT increased  $VO_{2max}$  4.3% in men and 8% in women. Additionally, lean body mass increased 1-3.2 kg, fat decreased 8-2.9%, and strength improved 7-32%. Finally, energy expenditure was found to be 9.6-9.9 kcals/min which when set to the appropriate time meets ACSM exercise guidelines (Gettman & Pollock, 1981; ACSM, 2010).

### **Relative Energy Expenditure (EE)**

**Effect of Interval Training on EE.** A study performed by Tremblay, Simoneau, and Bouchard (1994) looked at 18 to 32 year-old healthy individuals. Subjects performed either 20 weeks of endurance training or 15 weeks of HIT. The endurance training group cycled four times a week for 30-45 minutes at 60-85% of HRR. The HIT group performed either 4-5 bouts of 60-90 seconds or 10-15 bouts of 15-30 seconds at 70% of heart rate reserve. Subjects would then rest between sets until HR returned to 120-130 beats/minute. In this study it was observed that energy expenditure was twice as high in the endurance training group.

Knab et al. (2011) has also investigated the effects of cardiovascular exercise on EE. Subjects cycled 45 minutes at a vigorous level while in a metabolic chamber and it was found that  $519 \pm 60.9$  kcal were burned. Additionally, it was found that 14 hours after EE was increased  $190 \pm 71.4$  kcals compared to what is normally burned at rest. This accounts for a 37% addition to EE during exercise.

**Effects of Resistance Training on EE.** A study done by Wilmore et al. (1978) determined the energy cost of CWT. There were 40 subjects, both men and women who had experience in CWT. The workouts included a 5-minute warm-up, 22.5-minute resistance regimen, and a 12-minute cool-down. It was found that men burned 9.0 kcals/min and women burned 6.1 kcals/min. These calories per minute are similar to running at 5 mph and biking at 11.5 mph.

Robergs, Gordon, Renolds, and Walker (2007) investigated the effects of traditional resistance training on EE. He used indirect calorimetry during bench press and parallel squat. Recordings were taken for 5 minutes over several intensities on previously trained men. It was observed that resistance training expends up to 15 kcal/min when working at 60% intensity of 1-RM.

**Effects of Aerobic Dance on EE.** Energy expenditure during aerobic dance was examined by Rixon, Rehor, and Bemben (2006). Twenty-eight women participated in the study and were all asked to perform one of four different types of aerobic dance. Results found that 3 out of the 4 types of aerobic dance produced HR's that could produce cardiorespiratory benefits when being compared to ACSM (2010) guidelines. When looking at EE, it was found that the same 3 of 4 dance routines could burn more calories than jogging at 5 miles per hour. Finally, all four routines had energy expenditures that were above ACSM minimum guidelines per session (150-400 kcals), providing evidence for its validity to improve and/or maintain cardiovascular fitness.

**Effects of Group exercise on EE.** Additional studies have been done on cardio kickboxing and Zumba. Immel and Poracri (1999) studied cardio kickboxing and discovered an average intensity of 86% of HRmax and 73% of VO<sub>2</sub>max; subjects

expended an average of 8.1 kcal/min. Luetzgen and Foster (2011) found that a 40-minute Zumba session provides a workout that averages 80% of HRmax and 64% of VO<sub>2</sub>max, and expends 9.5 kcals/min. Both group exercise classes met ACSM (2010) guidelines.

EE during a boot camp workout were examined by Porcari, Hendrickson, and Foster (2008). Twelve men and women participated in the study and were all asked to perform a 40-minute boot-camp exercise video. Results showed that subjects exercised well within ACSM (2010) guidelines, working at an intensity of 77% of HRmax and 62% of VO<sub>2</sub>max. EE were also above ACSM minimum guidelines, averaging 9.8 kcal/min (392 kcals/workout), providing evidence for its validity to improve and/or maintain cardiovascular fitness and body composition.

A more recent study completed by Woldt, Porcari, Doberstein, Steffen, and Foster (2011) examined the physiological responses to four P90X workouts. Intensity across the four workouts ranged from 65-88% of HRmax and 45-80% of VO<sub>2</sub>max. Energy expenditure ranged from 7.2-16.2 kcals/min and subjects expended between 302-699 kcals per workout, exceeding ACSM (2010) guidelines.

**Effect of Intermittent and Continuous Exercise on EE.** It has long been debated if intermittent exercise is able to elicit the same cardiovascular effects as continuous endurance training. A study done by Peterson, Palmer, and Laubach (2004) showed that 3, 10-minute and 1 30-minute bout of walking expended a similar amount of calories. This provides evidence that breaking up your exercise into shorter bouts, but performing the same amount is as beneficial as doing it all in one increment.

## **Tabata**

The Tabata website (TabataTraining.org) claims that Tabata is better than endurance training because it requires less time, burns more fat, and provides superior aerobic and anaerobic benefits. Tabata claims time to be one of the reasons it's better because 1 session is 4 minutes long; containing 8 intervals of 20 seconds full out exercise bouts followed by 10 seconds of rest. Additionally, the website claims that Tabata increases both your HR and metabolism in seconds. They say this is important because you want your HR and metabolism high if your goal is to burn fat. Additionally, the site states that you're not only burning fat during exercise, but after as well. Finally, the claim that Tabata provides both anaerobic and aerobic benefits has been shown by a Japanese scientist named Izumi Tabata in 1996. Tabata et al. (1996) conducted a study comparing moderate intensity continuous training at 70% of  $VO_2max$  for 60 minutes, and high intensity interval training at 170% of  $VO_2max$  for 4 minutes. Intervals consisted of 8 20-second all-out exercise bouts followed by 10 seconds of rest for a total of 4 minutes of exercise (Tabata et al., 1996). The results of this study showed that HITT had a stronger relationship with improved aerobic capacity than moderate continuous training and produced an increase of 28% in anaerobic capacity, which aerobic training failed to do. Overall, Tabata claims to be better than endurance training since participants receive the same health and fitness benefits in a shorter period of time. It also claims to be more enjoyable as its intention is to allow one to input any exercise of his or her choice.

## **Conclusion**

Tabata training is an old idea that is being brought out in a new and creative way. Consisting of both HIIT and CWT, it has the potential to be a time efficient and effective option to attain a wide variety of health and fitness benefits. Although both HIIT and CWT have individually shown success in meeting ACSM guidelines for exercise prescription, the relative intensity and EE of Tabata is unknown. Therefore, it is essential to put Tabata to the test, and hold it accountable to the claims of time efficiency, fat loss, and aerobic/anaerobic benefits.

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