

UNIVERSITY OF WISCONSIN- LA CROSSE

Graduate Studies

HIGH INTENSITY INTERVAL TRAINING AND ENJOYMENT

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

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College of Science and Health
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HIGH INTENSITY INTERVAL TRAINING AND ENJOYMENT

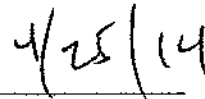
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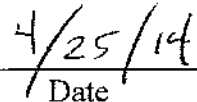
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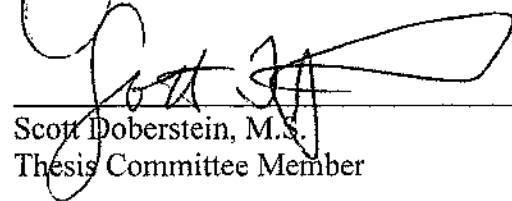
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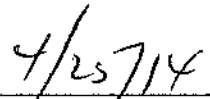
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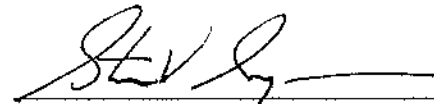


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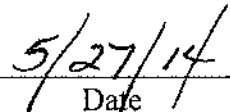


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ABSTRACT

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An increasing amount of attention is being given to enjoyment as a predictor of exercise adherence. Purpose: To investigate enjoyment levels during high intensity interval training. Methods: Sedentary college-aged students (n=55) participated in an eight week training intervention. The Exercise Feeling Inventory (EFI) and Exercise Enjoyment Scale (EES) were administered one day per week. Results: The EFI ANOVA indicated no statistical significance for both the revitalization and positive engagement subscales. Tranquility subscale scores were significantly higher for week five (-.183 mean) and week six (.109 mean). Physical exhaustion subscale scores were significantly higher in the Tabata group (2.211 mean). The EES ANOVA indicated pre-enjoyment scores were significantly lower for weeks four (3.228 mean) through eight (3.006 mean). The during-training enjoyment scores were significantly lower in the Tabata group (2.544 mean) and for weeks seven (2.793 mean) and eight (2.627 mean). The post-training enjoyment scores were significantly lower in the Tabata group (2.991 mean) and for weeks seven (3.104 mean) and eight (3.073 mean). Conclusion: The present study revealed that subjects randomly assigned to the Tabata training group yielded statistically higher EFI physical exhaustion subscale scores and statistically lower EES during and post-training enjoyment scores, consequent to an eight week training intervention.

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I would like to express gratitude towards the 55 subjects who made time in their busy schedules to participate in the study as well as the undergraduate volunteers who helped monitor training sessions.

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INTRODUCTION

The role of physical activity as a primary and secondary prevention intervention has been well established in the literature. Participating in regular exercise reduces the risk of all-cause mortality by 20-30% (Haskell et al., 2007). Yet, the majority of American adults do not satisfy the recommended guidelines for physical activity (“Health, United States”, 2014) and half of all those beginning an exercise regimen will stop within the first six months of training (Berry & Walsh, 2001). Adherence is thus a determining factor for the efficacy of any prescribed treatment intervention (Oldridge, 1991). Cognitive factors such as motivation and self-efficacy have been the primary focus in previous studies (McAulley et al., 2011). However, an increasing amount of attention is being given to enjoyment as a predictor of exercise adherence.

As demonstrated via a population-based postal survey of adults, high enjoyment of physical activity was associated with increased amounts of activity (Salmon, Owen, Crawford, Bauman, & Sallis, 2003). In male officers enrolled in the Finnish Police Academy, enjoyment of physical activity was the most significant determining factor of both physical fitness and physical activity (Sorensen, 2005). Among contestants in the 2002 senior games, physically active participants were predominantly motivated by fun or recreational enjoyment whereas improving quality of life was the primary motivator for their less active counterparts (Merrill, Shields, Wood, & Beck, 2004). In a school-based intervention designed to promote physical activity among adolescent females, both enjoyment of physical education and enjoyment of physical activity impacted

self-efficacy judgments regarding physical activity and mediated the outcome of the intervention (Dishman et al., 2005). In a health care-based intervention designed to promote physical activity among primary health care patients, variations in enjoyment were linked to variations in exercise level and demonstrated that health care-based interventions may influence enjoyment of physical activity (Hagberg, Lindahl, Nyberg, & Hellenius, 2009). Lastly, a study evaluating exercise interventions for older adults advocated the development of a new model with an emphasis towards enjoyment and satisfaction as opposed to motivation and behavior change (Thurston & Green, 2004).

Interval training may be superior to alternative methods of exercise training. High Intensity Interval Training (HIIT) is a discontinuous exercise approach that alternates short bouts of high intensity exercise with moderate intensity recovery periods. Research data indicates that HIIT may facilitate gains in both anaerobic and aerobic capacities whereas steady state training enhances maximal aerobic function but does not alter anaerobic capacity (Tabata et al., 1996). In addition, Tabata et al. (1996) concluded that exercising with HIIT yielded a greater overall improvement in maximal oxygen consumption (VO₂ max) compared with the steady state control group. A clinical application of interval training for CHF patients showed that HIIT enabled patients to perform greater workloads with lower cardiovascular stress compared with continuous training (Meyer et al., 1996).

Despite the proposed benefits of HIIT, it remains impractical to prescribe an exercise intervention that is not perceived as enjoyable by the participant. It is the aim of this study to investigate the enjoyment levels of sedentary college-aged students undergoing an eight week Tabata, Meyer, and steady state training intervention.

METHODS

Subjects

The subjects (n=65) were sedentary college students. The initial subject pool was narrowed by 10 subjects (n=55) through the course of training. Descriptive statistics of the remaining 55 subjects are presented in Table 1. The flow diagram in Figure 1 presents the progression of the study. Subjects deemed eligible for participation in the study completed both a Physical Activity Readiness Questionnaire (PAR-Q) and an exercise readiness questionnaire. Inclusion criteria included college-aged (18-27 years) students and sedentary individuals engaging in a maximum of two days of moderate-aerobic activity per week. Subjects were informed about the purpose, risk, and benefits of their involvement and written informed consent was collected from each subject. Approval from the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects was obtained prior to testing.

Table 1. Descriptive Statistics of Subjects (mean \pm SD).

	Steady State (19)	Tabata (21)	Meyer (15)
Age (yrs.)			
Males	19.5 \pm 1.38	20.3 \pm 2.14	19.3 \pm 1.26
Females	19.6 \pm 2.94	19.5 \pm 1.16	19.9 \pm 2.77
Height (cm.)			
Males	181.5 \pm 8.94	174.6 \pm 6.08	179.3 \pm 10.69
Females	164.8 \pm 4.87	168.6 \pm 3.93	164.9 \pm 4.85
Weight (kg.)			
Males	94.3 \pm 7.22	81.0 \pm 13.85	76.4 \pm 12.47
Females	68.6 \pm 15.12	68.2 \pm 14.04	71.9 \pm 18.55

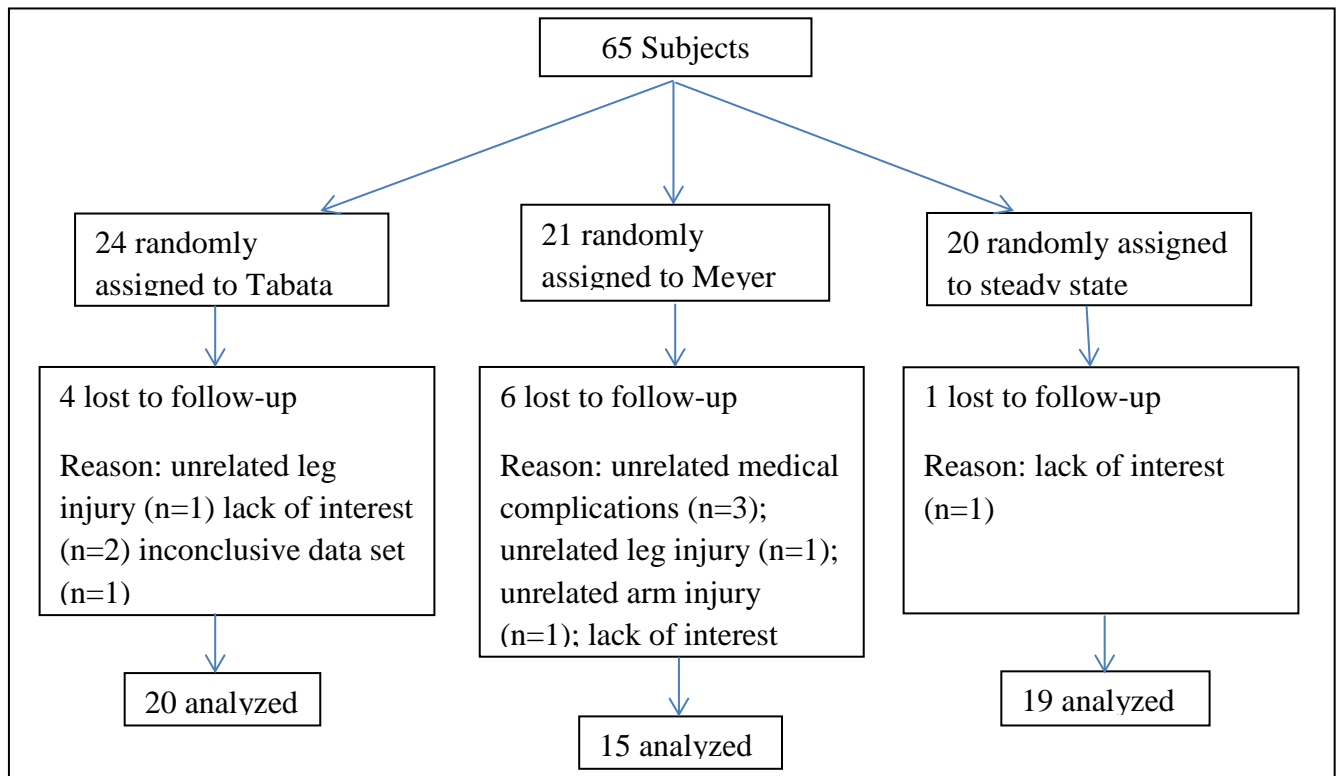


Figure 1. Progression of the eight week study.

PROCEDURES

The eight week study required subjects to attend three training sessions per week. Subjects were randomly assigned to one of three training groups including a Tabata, Meyer, and steady -state control group. The IE1 protocol was selected for the Tabata training group (Tabata et al., 1996). Subjects performed eight bouts of high-intensity exertion for 20 seconds, at 170% of VO_2 max, followed by a 10 second recovery period. All Tabata training was conducted on a Monark 874E Weight Ergometer Bike (Monark Exercise AB, Vansbro, Sweden). The Meyer training group consisted of high-intensity exertion for 30 seconds, at 100% of peak power output, followed by a 60 second recovery period. The average intensity was 90% of the ventilatory threshold (VT). The control group performed steady state exercise for 20 minutes at 90% of the power output at VT. All Meyer and steady state testing was conducted on a Monark 828E Test Ergometer (Monark Exercise AB, Vansbro, Sweden). One day per week subjects completed the Exercise-Induced Feeling Inventory (EFI) (Gauvin, & Rejeski, 1993) both pre and post workout. The EFI is comprised of twelve items that quantify four domains of interest: revitalization, tranquility, positive engagement, and physical exhaustion. Three items correspond to each domain, totaling twelve items: 1) refreshed, 2) calm, 3) fatigued, 4) enthusiastic, 5) relaxed, 6) energetic, 7) happy, 8) tired, 9) revived, 10) peaceful, 11) worn-out, and 12) upbeat. Subscale scores can be determined by averaging selected values for each item within a specific subscale. The four subscales contain: 1) revitalization (items 1, 6, & 9), 2) tranquility (items 2, 5, & 10), 3) positive engagement

(items 4, 7, & 12), and 4) physical exhaustion (items 3, 8, & 11). The Exercise Enjoyment Scale (EES) (Stanley, Williams, & Cumming, 2010) was also administered pre, during, and post-training to assess the subjects perceived level of enjoyment. A rank of zero indicated the absence of enjoyment while a rank of seven indicated high enjoyment. All subjects were directed to rank their perceived level of enjoyment at the exact moment in time the scale was administered.

STATISTICAL ANALYSIS

Change scores were calculated for each of the EFI subscales by subtracting the pre-workout score from the post-workout score. A two-way repeated measures ANOVA for a group x week design was performed to assess how the groups responded over the eight week training period. For the EES, separate two-way ANOVA's were run for the pre-workout, during-workout, and post-workout scores between groups over the eight week training period. In the case of a significant F-ratio, Fisher's LSD post-hoc multiple comparison tests were used to isolate differences between means. Alpha was set at .05 to achieve statistical significance. All data analysis was performed using IBM SPSS software (IBM, Armonk, NY).

RESULTS

The EFI subscale change scores are presented in Figure 2. The EFI ANOVA indicated no statistical significance for both the revitalization and positive engagement subscales. The revitalization subscale demonstrated no group effect with all three training groups exhibiting a downward trend in the last weeks of training. The positive engagement subscale varied widely from week to week with no trends of group effect.

Analysis of the tranquility subscale indicated no significant group or weeks x group interaction. A significant week effect was indicated as tranquility scores generally increased over the first six weeks of training, with no change thereafter. Specifically, the scores for week five (-.183 mean) and week six (.109 mean) were significantly higher compared to weeks one (-1.222 mean) and two (-1.375 mean).

Analysis of the physical exhaustion subscale revealed a slightly decreasing trend and indicated no significant week or weeks x group interaction. A significant group effect was indicated as the physical exhaustion scores were significantly higher in the Tabata training group (2.211 mean) compared to the control training group (.556 mean).

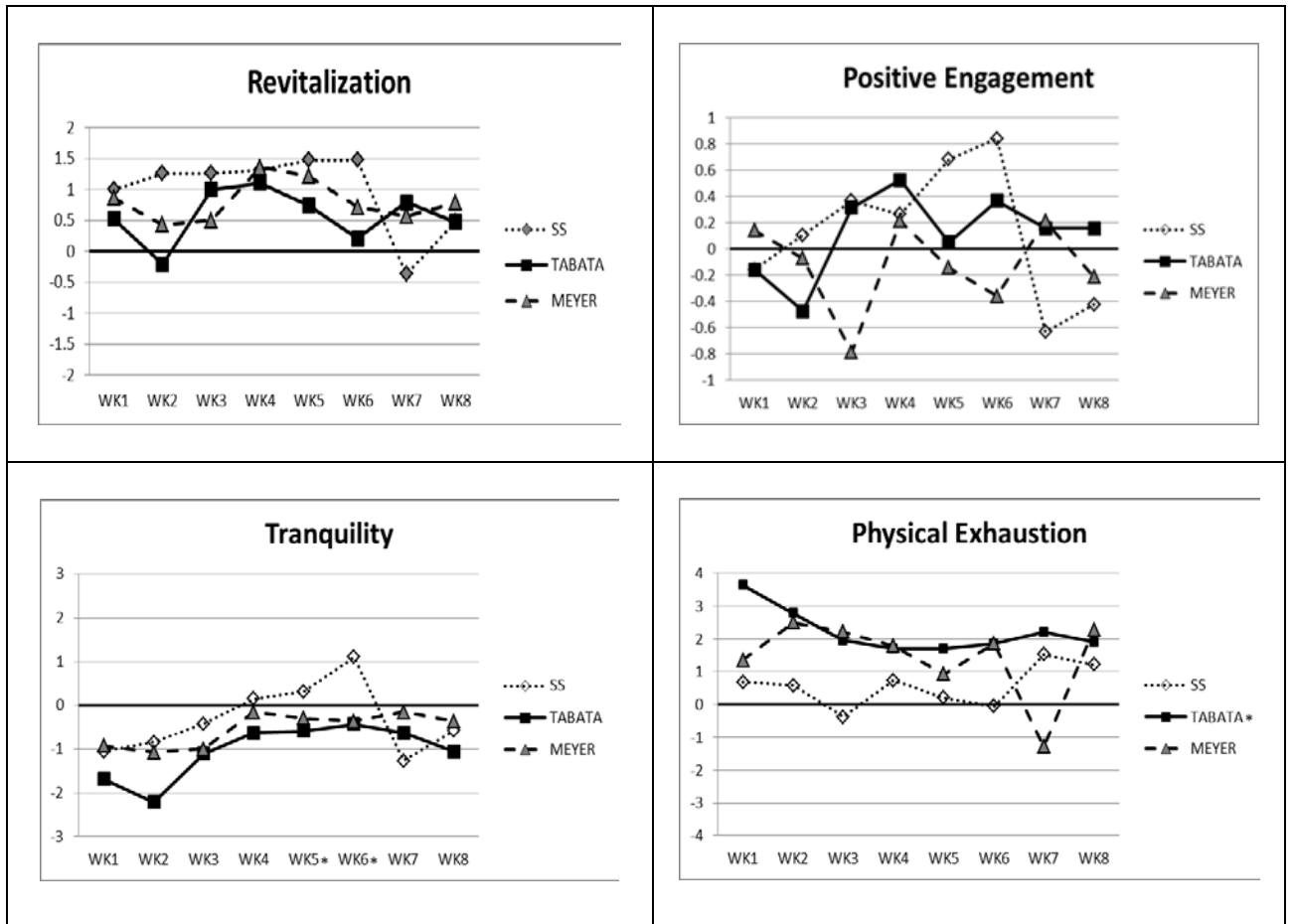


Figure 2. Changes in the EFI subscales for each group across the eight week study period.
 * - Tranquility scores are significantly higher in weeks five and six compared to weeks one and two.
 * - Physical exhaustion scores are significantly higher in the Tabata training group compared to the control training group.

The EES ANOVA indicated no significant group or weeks x group interaction for the pre-training enjoyment scores. There was a significant decrease in scores across the eight weeks of training. The scores for weeks four (3.228 mean) through eight (3.006 mean) were significantly lower when compared to week one (3.676 mean). The pre-training enjoyment data is presented in Figure 3.

Analysis of the during-training enjoyment scores indicated a significant week and group effect. The scores for week seven (2.793 mean) and week eight (2.627 mean) were

significantly lower compared to week one (3.210 mean). In addition, the during-training scores were significantly lower in the Tabata training group (2.544 mean) compared to the control training group (3.490 mean). The during-training enjoyment data is presented in Figure 4.

Analysis of the post-training enjoyment scores indicated a significant week and group effect. The scores for week seven (3.104 mean) and week eight (3.073 mean) were significantly lower compared to week one (3.718 mean). In addition, the post-training scores were significantly lower in the Tabata training group (2.991 mean) compared to the control training group (3.829 mean). The post-workout enjoyment data is presented in Figure 5. Effectively, the EES scores revealed a more negative sense of enjoyment of exercise across time with the Tabata group having generally lower scores than the control and Meyers training groups.

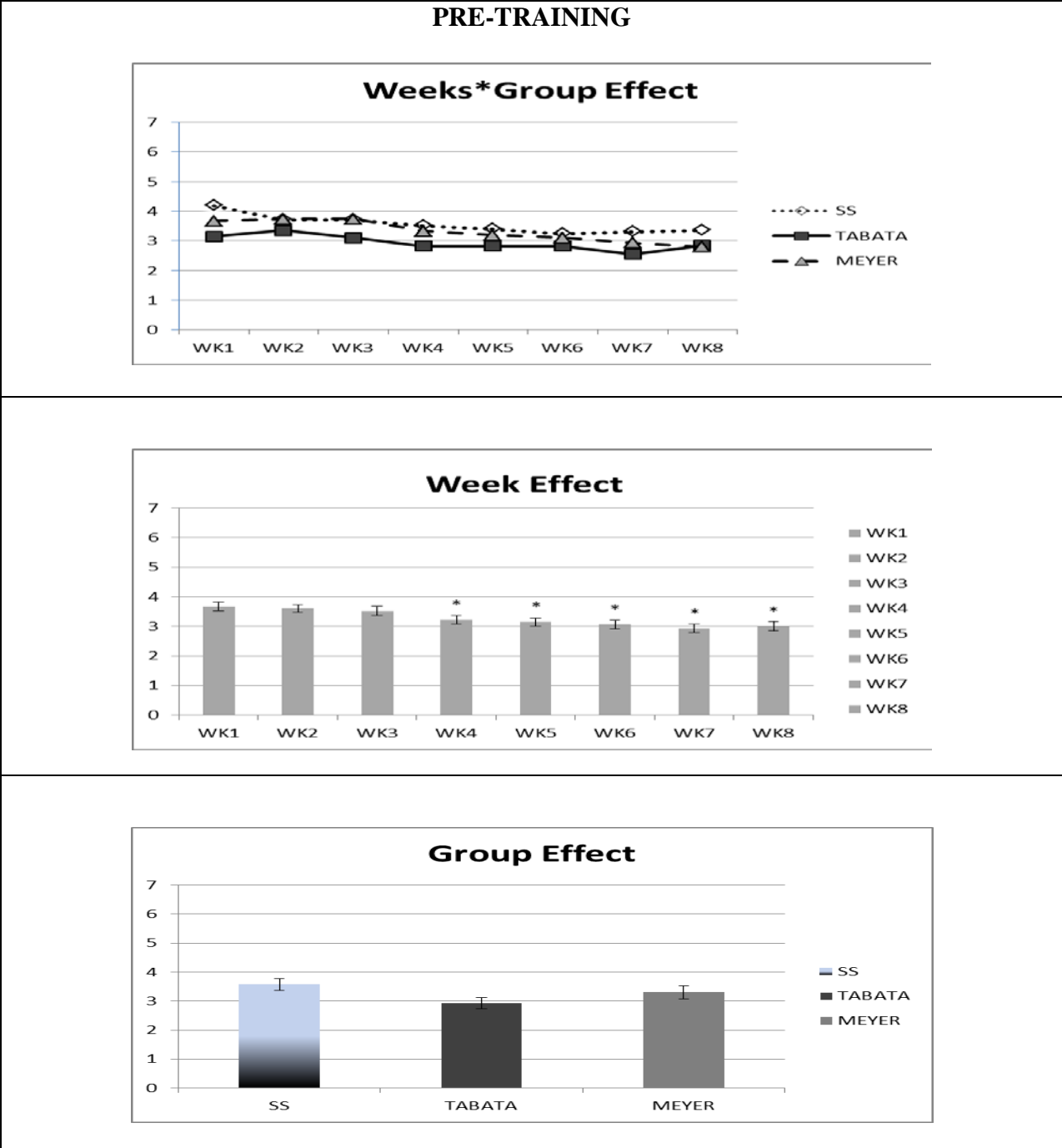


Figure 3. Pre-training responses on the EES questionnaire for each group across the eight week training period.
 * - Pre-testing enjoyment scores for weeks four through eight are significantly lower compared to week one.

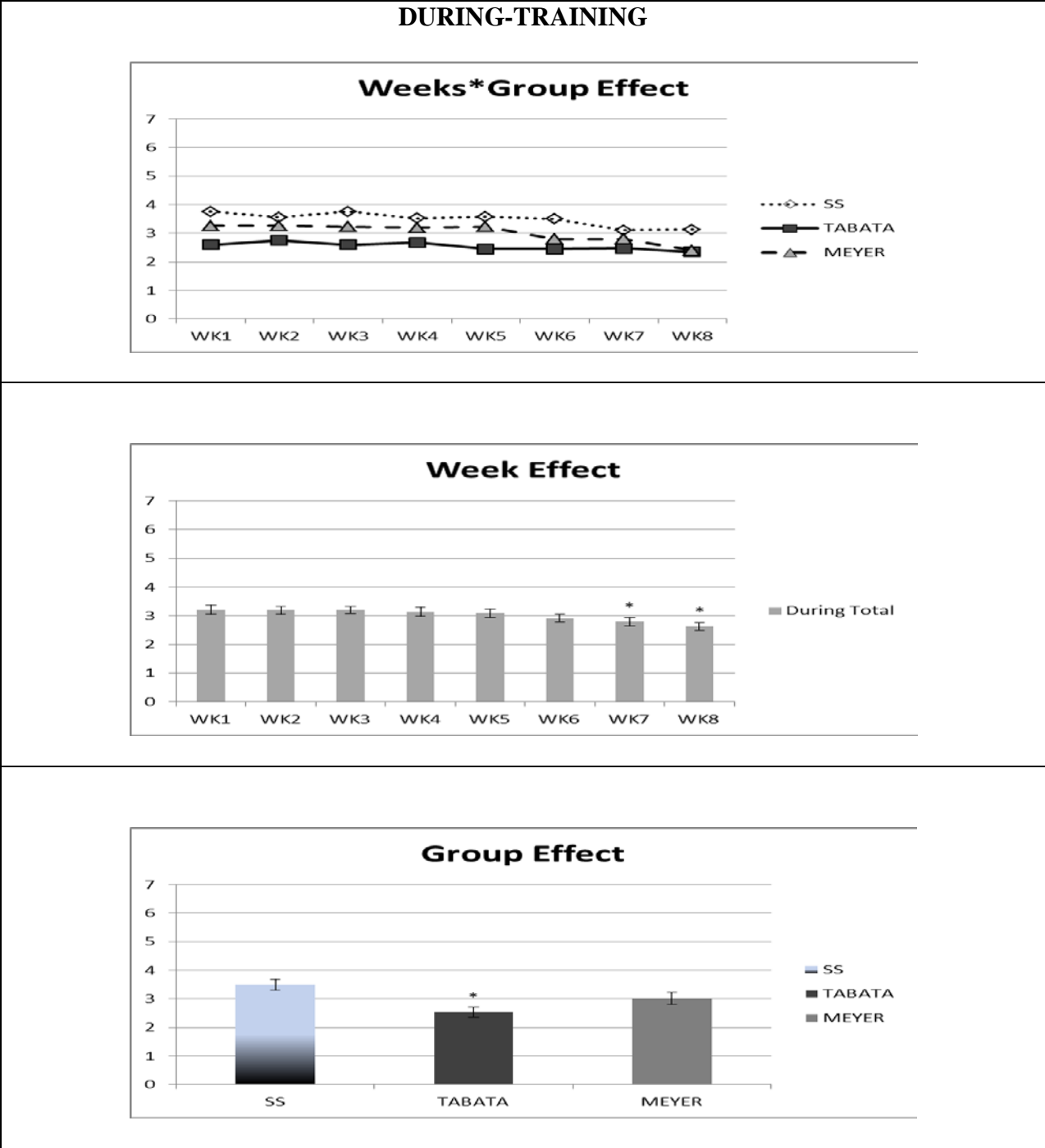


Figure 4. During-training responses on the EES questionnaire for each group across the eight week training period.

*- During-testing enjoyment scores for weeks seven and eight are significantly lower compared to week one.

*- During-testing enjoyment scores for the Tabata training group were significantly lower compared to the control training group.

POST-TRAINING

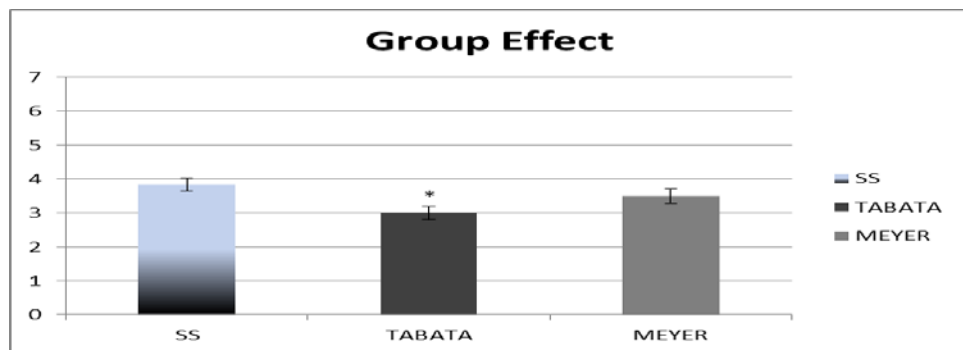
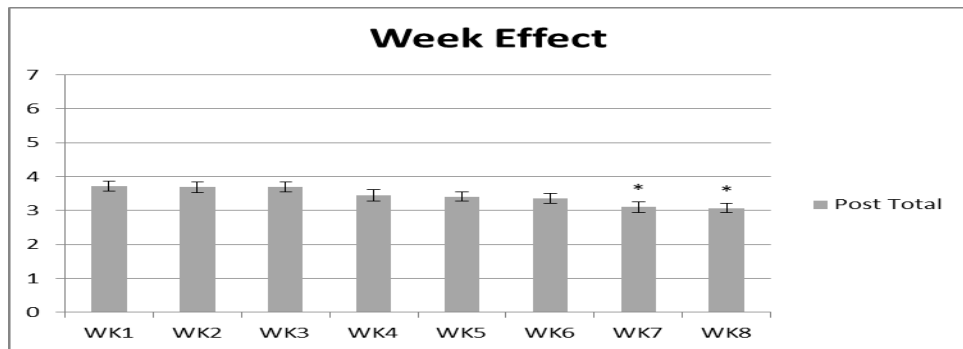
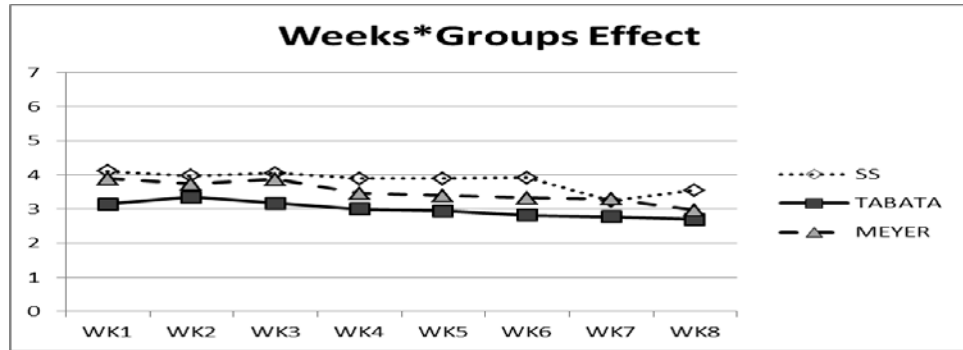


Figure 5. Post-training responses on the EES questionnaire for each group across the eight week training period.

* - Post-testing enjoyment scores for weeks seven and eight are significantly lower compared to week one.

* - Post-testing enjoyment scores for the Tabata training group were significantly lower compared to the control training group.

DISCUSSION

The purpose of this study was to investigate the enjoyment levels of sedentary college-aged students undergoing an eight week exercise training intervention. The interventions were either steady state aerobic training, a more moderate interval training program based on 30 seconds at peak power output with the overall intensity less than the VT (Meyer et al. 1996), or a very high intensity (170% VO₂ max) bout for 20 seconds followed by 10 seconds of rest, but performed for only four minutes (Tabata et al., 1996). The EFI revitalization and positive engagement subscales indicated no significant change through the eight weeks of training. These findings contradict data suggesting that nervous system and metabolic adaptations accompanying physical activity may facilitate feelings of refreshment (Thayer, 1989). Research also indicates that the mental health improvements associated with physical activity are potentiated by both physiologic function and biological factors. In a study of physically active women, participants were substantially happier in the recreational activity setting rather than a combination of household chores and recreational activities (Stephens, 1988).

Alternatively, these finding are supported by the works of Gauvin & Rejeski (1993) suggesting a significant correlation between both revitalization and tranquility to positive engagement. It is speculated that the factors driving positive engagement may fluctuate due to factors such as testing environment and physical properties of the activity. It is also proposed that revitalization feeling states are perhaps a prerequisite to

positive engagement feeling states. For instance, data indicates that feelings of positive affect such as joy are associated with high arousal (MacKinnon & Keating, 1989). The tranquility subscale scores exhibited a generally increasing trend and were significantly higher in weeks five and six of training. This finding supports the concept that the stress-buffering capability of physical activity may produce feeling states of peace and tranquility (Rejeski, Thompson, Brubaker, & Miller, 1992). Specifically, the calm experienced post-exercise may be linked to diminishing resting electromyographic activity and elevated electroencephalographic alpha wave activity.

The physical exhaustion scores were significantly higher in the Tabata training group compared to the Meyer and control training groups. Although the Tabata training group performed less total work, factors such as thermal discomfort, respiratory distress, metabolic depletion, and unfavorable sensations of muscles and joints may be more strongly associated with the very high intensity nature of Tabata training.

The EES pre, during, and post-training enjoyment scores indicated a significant week effect, as all three training groups exhibited a decreasing trend towards the end of the study. A plausible explanation may be that training overlapped with academic obligations, and many of the subjects were preoccupied with preparing for mid-term exams.

The during and post-training perceived enjoyment levels were significantly lower for the Tabata training group compared to the Meyer and control training groups. According to Gauvin & Rejeski (1993), psychosocial variables are most influential to the meanings attributed to biological events when exercising at moderate intensities. Unlike spontaneous training programs which have elements of self-selection, the ability to

individually modify the training program and the option for self scheduling training, the current training intervention was part of “a study” which necessarily removed many of the choices from the exercises. It should be of little surprise that enjoyment was low when self-choice is limited, especially when some of the elements (Tabata training) are physically demanding. Alternatively, the extreme stress of HITT is primarily influenced by physical cues as a result of their increase in perception. This notion is supported by the findings of this study as physical exhaustion scores were significantly higher in the Tabata training group, resulting in significantly lower during and post-training enjoyment scores.

CONCLUSIONS

The present study revealed that subjects randomly assigned to the Tabata training group yielded statistically higher EFI physical exhaustion subscale scores and statistically lower EES during and post-training enjoyment scores, consequent to an eight week training intervention. Despite the proposed benefits of HIIT, a low perceived enjoyment level may adversely affect subject adherence to exercise. Thus, a more moderate protocol (Meyer) or steady state training is recommended for untrained individuals.

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APPENDIX A
PHYSICAL ACTIVITY READINESS QUESTIONNAIRE

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

Yes or No	Has a doctor ever said that you have a heart condition and recommended only medically supervised activity? If yes, explain:
Yes or No	Do you have chest pain brought on by physical activity? If yes, explain:
Yes or No	Have you developed chest pain in the past month? If yes, explain:
Yes or No	Have you on one or more occasions lost consciousness or fallen over as a result of dizziness? If yes, explain:
Yes or No	Do you have a bone or joint problem that could be or has been aggravated by exercise? If yes, explain:
Yes or No	Has a doctor ever recommended medication for your blood pressure or a heart condition? If yes, explain:
Yes or No	Are you aware, through your own experience or a doctor's advice, of any other physical reason that would prohibit you from exercising without medical supervision? If yes, explain:

APPENDIX B
EXERCISE QUESTIONNAIRE

Comparative Effectiveness of Interval and Continuous Exercise Training

Name:

Age:

Gender:

Birth Date:

Email:

Phone Number:

Exercise History Questionnaire

1. What type of exercise routine have you participated in over this past summer?
2. How often do you exercise routinely? (min/days/week)
3. On a scale of 1 to 10, rate the intensity of your workout with 10 being maximal effort.
4. Please list any medications (over the counter or prescribed) that you are currently taking.

APPENDIX C
INFORMED CONSENT

INFORMED CONSENT

Purpose and Procedure

This study is designed to compare improvements in both aerobic and anaerobic exercise capacity resulting from exercise training using either steady state exercise or one of two types of widely used interval training methods.

My participation will involve 2 pre-tests (aerobic and anaerobic), 2 post-tests (same protocol, each requiring <60 min) and 3 exercise training sessions requiring ~30 min each week for 8 weeks. The testing and training may be very fatiguing.

Testing and training will take place in the Human Performance Laboratory, Mitchell Hall 225.

During the tests I will wear a snorkel-like device to analyze my breathing and a heart monitor, strapped around my chest, to monitor my heart rate. I may also have small blood samples taken from my finger tip. During training, I will also wear the heart rate monitor and have blood samples taken from my finger tip.

During both the tests and some training sessions, I will have to complete some questionnaires about how I feel about the training program and how I am feeling that day.

Potential Risks

The exercise tests, particularly the anaerobic tests are very fatiguing, and I will become very out of breath and my legs will be very tired. This may also occur if I am assigned to one of the interval training groups.

Individuals trained in CPR, Advanced Cardiac Life Support, and first aid will be in the laboratory, and the test will be terminated if complications occur.

The risk of serious or life-threatening complications, for healthy individuals, like myself, is near zero.

Rights and Confidentiality

My participation is voluntary. I can withdraw or refuse to answer any questions without any consequences at any time.

I can withdraw from the study at any time, for any reason, without penalty.

The results of this study may be published in the scientific literature or presented at professional meetings using group data only.

All information will be kept confidential through the use of number codes. My data will not be linked with personally identifiable information.

Possible Benefits

The primary benefit of this study is to the exercise community, and to the ability of exercise professionals to better serve their clients. Individually I should experience a 10-25% increase in my exercise capacity, which is generally associated with being healthier. By participating in a research project, I may find that my academic experience at UWL is richer.

Questions regarding study procedures may be directed to Professor Foster (608 785 8687 or cfoster@uwlax.edu), the principal investigator, or Chris Dodge, laboratory manager of the Human Performance Laboratory (608 785 8681 or cdodge@uwlax.edu). Questions regarding the protection of human subjects may be addressed to the UW-La Crosse Institutional Review Board for the Protection of Human Subjects, (608 785 8124 or irb@uwlax.edu).

Participant _____ Date _____

Researcher _____ Date _____

APPENDIX D

EXERCISE FEELING INVENTORY

HOW ARE YOU FEELING? (PRE -EXERCISE)

Instructions: Please use the following scale to indicate the extent to which each word below describes how you feel at this moment in time. Record your responses by ticking the appropriate box next to each word

	FEELING	Do not feel	Feel slightly	Feel moderately	Feel strongly	Feel very strongly
RV	1. Refreshed	()	()	()	()	()
TD	2. Calm	()	()	()	()	()
PHY	3. Fatigued	()	()	()	()	()
PE	4. Enthusiastic	()	()	()	()	()
TD	5. Relaxed	()	()	()	()	()
RV	6. Energetic	()	()	()	()	()
PE	7. Happy	()	()	()	()	()
PHY	8. Tired	()	()	()	()	()
RV	9. Revived	()	()	()	()	()
TD	10. Peaceful	()	()	()	()	()
PHY	11. Worn-out	()	()	()	()	()
PE	12. Upbeat	()	()	()	()	()

Use the following scale to indicate how much you will enjoy the upcoming exercise session:

1	2	3	4	5	6	7
Not at all	Very little	Slightly	Moderately	Quite a bit	Very much	Extremely

HOW ARE YOU FEELING? (POST-EXERCISE)

Instructions: Please use the following scale to indicate the extent to which each word below describes how you feel at this moment in time. Record your responses by ticking the appropriate box next to each word

	FEELING	Do not feel	Feel slightly	Feel moderately	Feel strongly	Feel very strongly
RV	1. Refreshed	()	()	()	()	()
TQ	2. Calm	()	()	()	()	()
PHY	3. Fatigued	()	()	()	()	()
PE	4. Enthusiastic	()	()	()	()	()
TQ	5. Relaxed	()	()	()	()	()
RV	6. Energetic	()	()	()	()	()
PE	7. Happy	()	()	()	()	()
PHY	8. Tired	()	()	()	()	()
RV	9. Revived	()	()	()	()	()
TQ	10. Peaceful	()	()	()	()	()
PHY	11. Worn-out	()	()	()	()	()
PE	12. Upbeat	()	()	()	()	()

Scoring:

Use the following key to score each item:

- 0 = Do not feel
- 1 = Feel Slightly
- 2 = Feel Moderately
- 3 = Feel Strongly
- 4 = Feel very strongly

EFI consists of 4 distinct subscales; Positive Engagement (PE), Revitalization (REV), Tranquility (TQ), Physical Exhaustion (PHY). Add together the 3 relevant items for each subscale. Calculate the subscale scores for both pre and post exercise.

Exercise Induced Feeling Inventory
Gauvin & Rejeski (1993)

APPENDIX E

EXERCISE ENJOYMENT SCALE

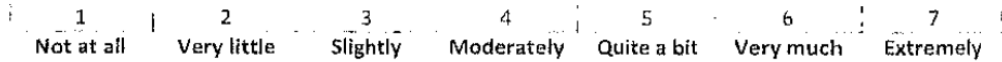
Exercise Enjoyment Scale

Damian M. Stanley and Jennifer Cumming

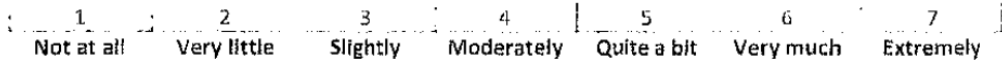
University of Birmingham

There are three different versions of the scale.

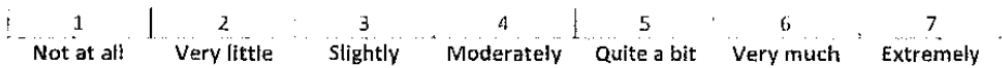
Use the following scale to indicate how much you will **enjoy** the upcoming exercise session:



Use the following scale to indicate how much you are **enjoying** this exercise session:



Use the following scale to indicate how much you **enjoyed** the exercise session:



Reference for the scale:

Stanley, D. M., & Cumming, J. (2010). Are we having fun yet? Testing the effects of imagery use on the affective and enjoyment responses to acute moderate exercise. *Psychology of Sport and Exercise*, 11, 582-590.

Validation of the scale has been reported here:

Stanley, D. M., Williams, S. E., & Cumming, J. (2009). Preliminary validation of a single-item measure of exercise enjoyment: The Exercise Enjoyment Scale. *Journal of Sport and Exercise Psychology*, 31, 5138-139

APPENDIX F
REVIEW OF THE LITERATURE

REVIEW OF LITERATURE

Physical Activity Guidelines

Revised guidelines, 2007, issued by the American College of Sports Medicine (ACSM) and American Heart Association (AHA) recommend all physically able adults partake in moderate-intensity physical activity for at least 30 minutes per day for five days a week or vigorous-intensity training 20 minutes per day for three days (Pescatello, Arena, Riebe, & Thompson, 2014). Furthermore, training regimens should incorporate eight to 10 muscular-strengthening exercises involving all the major muscle groups with eight to 12 repetitions on at least two days per week. Adherence to ACSM guidelines has been associated with positive health outcomes such as improved bone density, maintenance of type II diabetes, weight reduction, improved mental outlook, and improved quality of life (“Physical activity and”, 2011). However, data collected by the Centers for Disease Control and Prevention (CDC) indicates that only 48.4% of adults satisfy physical activity guidelines for aerobic conditioning. Additionally, 24% of adults aged 18 and older in the United States satisfied muscular-strengthening guidelines with only 20.6% of the adult population meeting both aerobic and muscular-strengthening guidelines (“Health, United States”, 2014).

Population Trends

According to Keating, Silverman, & Kulinna (2002), physical activity levels taper-off during adolescence. Of concern is data provided by McKenzie & Sallis (1996) which reports that physically inactive children are prone to become sedentary adults. Common barriers to physical activity include lack of time, facilities, support, education, motivation, energy, as well as poor diet, and competing interests. The reduction of physical activity has amplified the prevalence of childhood and adulthood obesity, as well as the associated health outcomes. On the front lines of this epidemic, the establishment of cardiovascular risk-reduction programs have served to profoundly reduce all-cause mortality rates by 20-30% (Wenger, 1995) Nevertheless, the efficacy of cardiovascular rehabilitation programs is strongly influenced by four factors: 1) the detection of symptomology, 2) accurate diagnosis, 3) appropriate treatment protocol, and 4) patient adherence to the prescribed treatment interventions (Oldridge, 1991).

Adherence

Adherence, or the absence of it, is a determining factor to the efficacy of any prescribed treatment. Furthermore, non-adherence may affect people of all ages, gender, socioeconomic status, and can vary throughout the course of treatment. Data suggests that non-adherence often arises early in treatment with an estimated 50% of participants withdrawing from exercise programs before the first six months (Berry & Walsh, 2014). In addition, women are less likely to participate and are more prone to withdraw from cardiac rehabilitation programs (Balady et al., 2012). Specifically, comorbidities, lack of interest, and musculoskeletal ailments are attributing factors to women withdrawing from

participation (Marzolini, Brooks, & Oh, 2008). Over longer durations adherence rates continue to decrease but, at a less drastic rate than initially observed. According to Dishman (1982), dropout rates from physical activity displays a negative accelerating progression across time. Accordingly, the dual challenges of motivating tentative patients to actively alter risk factors and providing the appropriate strategies to facilitate this goal must be given special consideration.

Self-Efficacy

A crucial aspect of patient adherence, the notion of self-efficacy is a central component of Albert Bandura's Social Cognitive Theory. As reported by Bandura (1982), self-efficacy is a personal belief in her or his capability to successfully perform a specific task. Individuals with high self-efficacy view difficult tasks as skills to be mastered, are more dedicated to the task, and are more apt to recover from setbacks. Individuals with low perceived self-efficacy avoid difficult tasks, believe they do not have the capabilities to master challenging tasks, display reduced self-confidence, and focus on negative outcomes and personal shortcomings. These personal beliefs begin to develop as children receive feedback through various situations, tasks, and experiences. However, self-efficacy continues to evolve throughout an individual's lifespan as they acquire new experiences, understandings, and skills. Bandura (1994) identifies four distinct sources that influence self-efficacy including: 1) mastery experiences, 2) vicarious experiences, 3) verbal persuasion, and 5) physiological state. Mastery experiences entail successfully completing a given task, which serves to strengthen an individual's perceived self-efficacy. However, failing to complete a challenge may

weaken self-efficacy. Vicarious experiences include imitating the skills and strategies utilized by a model to improve self-efficacy. Verbal persuasion suggests that comments of positive effect may persuade an individual to overcome self-doubt and accomplish a challenging task. Conversely, comments of negative affect may undermine an individual's self-efficacy. Lastly, an individual's physiological responses to stress influences self-efficacy. Emotional states, diaphoresis, tachycardia, and anxiety may all impact and individuals perception of their ability to accomplish a task. In addition to these four sources, healthcare professionals may improve patient self-efficacy levels by providing in-depth feedback, facilitating social modeling experiences, and prescribing treatment protocols that are mutually challenging and attainable.

Enjoyment

Most of the research regarding the predictors of exercise adherence has evaluated cognitive factors, including self-efficacy (McAulley et al., 2011). Nonetheless, there remains data supporting the correlation between enjoyment and physical activity. As demonstrated via a population-based postal survey of adults, high enjoyment of physical activity was associated with elevated amounts of activity (Salmon, Owen, Crawford, Bauman, & Sallis, 2003). In addition, in male officers enrolled in the Finnish Police Academy, enjoyment of physical activity was the most significant determining factor of both physical fitness and physical activity (Sorensen, 2005). Among contestants in the 2002 senior games, physically active participants were predominantly motivated by fun or recreational enjoyment whereas improving quality of life was the primary motivator for their less active counterparts (Merrill, Shields, Wood, & Beck, 2004). In a

school-based intervention designed to promote physical activity among adolescent females, both enjoyment of physical education and enjoyment of physical activity impacted self-efficacy judgments regarding physical activity and mediated the outcome of the intervention (Dishman et al., 2005). In a health care-based intervention designed to promote physical activity among primary health care patients, variations in enjoyment were linked to variations in exercise level and demonstrated that health care-based interventions may perhaps influence enjoyment of physical activity (Hagberg, Lindahl, Nyberg, & Hellenius, 2009). Additionally, a study evaluating exercise interventions for older adults advocated the development of a new model with an emphasis towards enjoyment and satisfaction as opposed to motivation and behavior change (Thurston & Green, 2004).

Exercise-Induced Feeling Inventory

The Exercise-Induced Feeling Inventory (EFI) was designed upon the assumption that stimulus properties associated with physical activity yield distinct feeling states. First, it is established that physical activity results in increased sympathetic nervous system activation. In addition, data suggests that nervous system and metabolic adaptations accompanying physical activity may facilitate feelings of refreshment (Thayer, 1989 & Gauvin & Rejeski, 1993). Second, evidence indicates that the stress-buffering capability of physical activity may produce feeling states of peace and tranquility (Rejeski, Thompson, Brubaker, & Miller, 1992 & Gauvin & Rejeski, 1993). Specifically, the calm experienced post-exercise can be linked to diminishing electromyographic activity and elevated electroencephalographic brain alpha wave

activity. Third, research indicates that the mental health improvements associated with physical activity are potentiated by both physiologic function and biological factors including the external environment, social context, and its personal value. In a study of physically active women, participants were substantially happier in the recreational activity setting rather than a combination of household chores and recreational activities (Stephens, 1988 & Gauvin & Rejeski, 1993). Finally, fatigue has been a well-researched mediator of physical activity. Factors such as thermal discomfort, respiratory distress, metabolic depletion, and unfavorable sensations of muscles and joints impact perceptions of fatigue.

Accordingly, the EFI is comprised of 12 items that quantify four domains of interest: revitalization, tranquility, positive engagement, and physical exhaustion. Three items correspond to each domain, totaling 12 items: 1) refreshed, 2) calm, 3) fatigued, 4) enthusiastic, 5) relaxed, 6) energetic, 7) happy, 8) tired, 9) revived, 10) peaceful, 11) worn-out, and 12) upbeat. Subscale scores can be determined by averaging the selected values for each item within a specific subscale. The four subscales contain: 1) revitalization (items 1, 6, & 9), 2) tranquility (items 2, 5, & 10), 3) positive engagement (items 4, 7, & 12), and 4) physical exhaustion (items 3, 8, & 11). A zero to four visual analog scale enables participants to efficiently self-rate the magnitude of each feeling state. These states are illustrated by one-word adjectives rather than drawn out statements or sentences. Items were derived from two sources: the affective lexicon and items contained in the Activation Deactivation Adjective Check List (AD-ACL), Profile of Mood States (POMS), and State-Trait Anxiety Inventory (STAI). The relevancy of each item was assessed by three expert exercise psychologists and validated through a survey

of moderately active college student enrolled at a large Canadian university (Gauvin & Rejeski, 1993).

Although pre-existing instruments such as the POMS, STAI, and Positive Affect Negative Affect Schedule (PANAS) have been well established in the literature, such tools have limitations in the realm of acute training. One criticism is that current measures and the associated research have primarily focused on negative affect (Argyle & Crossland, 1987 & Gauvin & Rejeski, 1993). For instance, the vigor subscale is the only positive affect measure on the POMS instrument. This is a significant limitation as data suggests that physical activity may be more strongly associated with positive as opposed to negative affect (Gauvin & Brawley, 1993 & Gauvin & Rejeski, 1993). Another relevant criticism may be the content and construct validity of existing measures. Failing to establish appropriate content validity is a serious limitation in that significant theoretical constructs remain undetected. This in turn directly impacts theory development and can mitigate the efficacy of exercise prescription. Also of concern is the issue of construct validity. For instance, initial studies utilizing the STAI suggested that participants experienced increased anxiety during acute physical activity (Morgan & Horstman, 1976 & Gauvin & Rejeski, 1993). However, alternate data indicates that what was thought to be exercise-induced state anxiety may in actuality be increased arousal (Rejeski, Hardy, & Shaw, 1991 & Gauvin & Rejeski, 1993). Ultimately, the STAI does not adequately distinguish between negative and positive arousal states. The work of Gauvin and Rejeski (1993) produced five studies in which the EFI instrument demonstrated adequate content validity, construct validity, and internal reliability. The

series of studies also indicated that the EFI was sensitive enough to measure social dimensions and manipulations of physical activity.

High-Intensity Interval Training

High Intensity Interval Training (HIIT) is an exercise approach that alternates short bouts of high intensity exercise with moderate intensity recovery periods. Despite an abundance of literature, a standardized protocol has not been established in regards to the most efficacious intensity, mode of training, exercise duration, and recovery duration. The Tabata regimen is a variation of HIIT that evolved from the works of Professor, Izumi Tabata (Tabata et al., 1996). The original six week study utilized seven to eight bouts of high-intensity exertion for 20 seconds, at approximately 170% of VO₂ max, followed by a 10 second recovery period between bouts. Tabata et al. (1996) coined this method the IE1 protocol and all testing was conducted on a mechanically braked ergometer cycle. The subjects using the intermittent technique trained four days per week, plus an additional day of moderate-intensity aerobic training, and experienced benefits comparable to subjects training 30 minutes per day at 70% of VO₂ max for five days per week. The data revealed that the steady state training group obtained higher VO₂ max values at the termination of the study, improving from 53 ml·kg⁻¹·min⁻¹ to 58 ml·kg⁻¹·min⁻¹, however the HIIT group demonstrated a greater overall improvement in VO₂ max (7 ml·kg⁻¹·min⁻¹) with a final value of 55 ml·kg⁻¹·min⁻¹. Moreover, it is suggested that HIIT may facilitate gains in both anaerobic and aerobic capacities whereas steady state training enhances maximal aerobic function but does not alter anaerobic capacity. The subsequent year, Tabata and colleagues (1997) conducted a follow-up

investigation comparing two frequently employed protocols, the IE1 and IE2. The IE2 consisted of four to five cycles of high-intensity exertion for 30 seconds, at approximately 200% of VO₂ max, followed by a two minute recovery period between cycles. Once again the IE1 protocol emerged dominant as this method of training yielded favorable improvements in both anaerobic and aerobic capabilities. Although the IE2 group performed more total work overall, the ample two minute recovery period was ineffective in accumulating an oxygen deficiency necessary to enhance anaerobic function. In another study, aerobic endurance protocols with equivalent total workloads but differing intensities and methods were assessed (Helgerud et al., 2007). Subjects were randomly appointed to one of four training protocols: 1) steady state running at 70% of maximal heart rate (HR_{max}), 2) lactate threshold running at 85% of HR_{max}, 3) high-intensity running for 15 seconds at 90-95% of HR_{max} with 15 seconds of active recovery at 70% of HR_{max}, and 4) high-intensity running for four minutes at 90-95% of HR_{max} with three minutes of active recovery at 70% of HR_{max}. High-intensity aerobic training resulted in substantial improvements in Vo₂ max with the 15x15 and 4x4 protocols yielding 5.5% and 7.2% increases, respectively. Stroke Volume (SV) also showed significant improvements yielding 10% increase post interval training.

Sprint Interval Training

Sprint Interval Training (SIT) is a discontinuous form of exercise that alternates short bouts of maximal physical exertion with moderate intensity recovery periods. The effects of SIT were assessed in a study of recreationally active college students (Burgomaster, Hughes, Heigenhauser, Bradwell, & Gibala, 2005). Subjects were

required to attend a total of six training sessions over the duration of 14 days with one to two days of recovery between sessions. Each session was comprised of four to seven Wingate tests with 30 seconds of maximal exertion, at 80% of VO₂ max, followed by a four minute recovery phase between tests. SIT enhanced metabolic function in that citrate synthase activity and resting muscle glycogen stores increased by 38% and 26%, respectively. Despite no change in VO₂ max, cycle endurance capacity also yielded 100% increase. The effects of SIT on overweight and obese men were investigated in a similar study (Whyte, Gill, & Cathcart, 2010). A total of six mandatory training sessions required subjects to perform four to six Wingate tests with 30 seconds of maximal exertion and four minutes of recovery between tests. After SIT, significant improvements in VO₂ max and mean power was observed. In addition, resting fat oxidation and insulin sensitivity were higher while resting carbohydrate oxidation and systolic blood pressure were lower. In another study, the previously established 30sec/4min SIT protocol was compared to a low volume HIIT method (Bayati, Farzad, Gharakhanlou, & Agha-Alinejad, 2011). Subjects were required to attend a total of three sessions per week over the duration of four weeks. The HIIT regimen consisted of six to 10 bouts with 30 seconds of maximal exertion, at 125% power at VO₂ max (P_{max}), followed by a two minute recovery period. Post training, both protocols showed significant improvements in VO₂ max, P_{max}, time to exhaustion (T_{max}), and peak power output. However, the significance of mean power output was only indicated in the SIT protocol.

Clinical Application

In 1963, a cardiologist by the name Dr. Vojin Smodlaka applied interval training to treat cardiac rehabilitation patients. The Smodlaka (1963) experiment concluded that intermittent training protocols were of relevant safety to continuous exercise and may be more efficacious in reconditioning the heart. The data also indicated that more total intervals correlated with lower resting heart rates. The finding is supported by a similar study of stable coronary heart disease (CHD) patients endorsing the utilization of more total intervals (Guiraud et al., 2010). The data indicated that HIIT for 15x15sec with passive recovery phases induced more physiologic gains than active recovery phases or continuous exercise. Although passive recovery protocols required longer exercise durations to achieve exhaustion and thus required more total work, time at VO₂ max was comparable to active recovery and continuous protocols. A longer T_{max} may be an advantage in the clinical setting as was demonstrated by a study of coronary bypass patients (Meyer, Lehmann, Sunder, Keul, & Weidemann, 1990). The study showed that bouts of interval training followed by one minute active recovery periods were favorable to continuous training. Interval training enabled the patients to prolong their exercise sessions, thus completing more total work per session. In addition, the anaerobic and aerobic mechanisms of interval training made it a preferred method over continuous training for CHD patients. In a study of patients with chronic heart failure (CHF), three interval training protocols with different work-to-rest ratios and work rates were assessed (Meyer et al., 1996). Subjects trained in one of three groups: 1) 30/60 at 50% of max work rate, 2) 15/60 at 70% of max work rate, and 3) 10/60 at 80% of max work rate. Although no significant differences were indicated, the lower intensity protocol was

recommended as it enabled patients to perform greater workloads with reduced cardiovascular stress compared to continuous training at 75% of VO₂max. In another study of CHF patients, interval training protocols with different modes of training were investigated (Meyer et al., 1997). Both training modes resulted in acceptable physical responses however, HIIT training allowed participants to perform a higher workload with lower cardiovascular strain compared to steady state training.

Total work vs. Intensity

For many adults, intense interval training is a time-efficient means of improving anaerobic and aerobic capacity (Gibala & McGee, 2008). Nevertheless, there remains uncertainty regarding the correlation between total work performed and optimal training intensity. A study of stable coronary artery disease (CAD) patients compared HIIT to moderate intensity exercise (Rognmo, Hetland, Helgerud, Hoff, & Slordahl, 2004). The total workload was matched for protocols as patients walked on a treadmill three days per week over the duration of 10 weeks at either 50-60% of VO₂ max or 80-90% of Vo₂ max. The data showed that HIIT resulted in a 17.9% increase in VO₂ max compared to a 7.9% increase from moderate training. Because the two protocols were controlled for total work performed, the study suggested that high intensity training is the dominant factor in improving aerobic capacity in CAD patients. The Helgerud et. al. (2007) study found similar results concluding that training intensity was the more dominant factor in mediating physiologic response. Contrary to the notion, a study of trained recreational cyclists investigated three interval training protocols with different intensities (Seiler, Joranson, Olesen, & Hetleid, 2013). Subjects were randomized into one of three groups:

1) 4x4 min at 88% of HRmax, 2) 4x8 min at 90% of HRmax, and 3) 4x16 min at 95% of HRmax. The study demonstrated that by reducing the training intensity and prolonging the exercise duration, cyclists training at 90% of HR max experienced more significant gains in VO2 max, Pmax, and mean power output values than athletes training at 95% of HR max. Ultimately, the data indicates that both total work performed and training intensity may be mutually important factors to physiologic adaptation.

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