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Comparing energy expenditures between a circuit weight training protocol and a steady state aerobic activity

Breann M. Booher
Eastern Washington University

COMPARING ENERGY EXPENDITURES BETWEEN A CIRCUIT WEIGHT TRAINING PROTOCOL AND A STEADY STATE AEROBIC ACTIVITY

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Breann M. Booher

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THESIS OF BREANN M. BOOHER APPROVED BY

____ DATE ________________________
Dr. Christi Brewer; Chair

____ DATE ________________________
Nathaniel Lawton; Committee Member

____ DATE ________________________
Angela Schwendiman; Committee Member

MASTER'S THESIS

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ABSTRACT

Circuit weight training (CWT) is currently at the forefront of the fitness industry. During the past 10 years, its popularity has increased due to its ability to combat common deterrents of exercise program adhesion. Many individuals that utilize CWT not only use it to fulfill their weekly exercise requirements, but are looking to maintain or lose weight as well. The purpose of this study was to compare the energy expenditures (EE) in total kcals and average rate of perceived exertion (RPE) values of a 20 min CWT protocol and a 20 min steady state aerobic protocol of equivalent intensity based on an individual's average heart rate during the CWT protocol. The CWT protocol consisted of 10 machine weight stations: chest press, leg press, latissimus pull down, shoulder press, hamstring curl, leg extension, assisted pull-up, pec fly, seated row, and back extension. EE was calculated by means of indirect calorimetry by the Cosmed K4 b^2© (Rome, Italy) and heart rate (HR) was monitored by means of a FT1 Polar heart rate monitor (Polar Electro, Kempele, Finland). RPE values were taken at the end of every 4^{th} CWT station and every 2 min during the steady state aerobic activity. Paired samples t-tests revealed significant differences in EE and average RPE values during the CWT protocol and steady state aerobic activity. While EE values were greater during the steady state aerobic activity, RPE values were higher during the CWT protocol. These findings add to the limited literature on EE and RPE during CWT and steady state aerobic activity of equivalent intensities.

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TABLE OF CONTENTS

LIST OF TABLES

Table

LIST OF FIGURES

Figure

Chapter 1

Introduction

Every year, novel exercise regimens and modalities are introduced to the world of fitness. In the past 10 years, there has been an increase in popularity with programs such as CrossFit™, P90X™, and Insanity™. A common characteristic of these programs is the use of high-intensity, short duration exercises to limit the total amount of time spent exercising. These training regimens appeal to individuals because they address a major deterrent associated with fitness participation - time. Lack of time is often cited as a barrier to exercise participation and may result in a lack of adherence to an exercise program or abstention from exercise participation.

Circuit weight training (CWT) is one of the methods utilized by fitness programs like CrossFit™. CWT first found its way into the fitness industry in the late 1970s and has since undergone much change (Gettman, Ayres, Pollock & Jackson, 1978). Modern CWT utilizes a planned exercise order that can be dictated by the order in which machine weight stations are placed within a gym. The participant is then able to perform the exercises in a continuous manner while minimizing rest and maximizing exercise density during their workout. Instead of having to take the time to perform aerobic and resistance training, participants feel as if they are getting an adequate amount of both from CWT (Skidmore, Jones, Blegen & Matthews, 2012). CWT can be altered to train for a number of different goals related to physical fitness such as body composition, muscular strength, and aerobic capacity (Gettman, Ayres, Pollock & Jackson, 1978; Mosher, Underwood, Ferguson & Arnold, 1994; Paoli et al., 2010). This can be accomplished by altering the load, the number of repetitions, order of the exercises, or the rest period. While CWT began as a means for untrained individuals to train, it has found increasing popularity in a number of realms including, but not limited to athletic populations, firefighters, the military, and youth athletes (Skidmore, Jones, Blegen & Matthews, 2012).

Lack of exercise is one of the many factors playing into one of the worst global health pandemics of all time. Worldwide obesity rates have more than doubled since 1980. Currently, more than 1.9 billion adults (>18 years of age) are overweight, with 600 million of those individuals falling into the category of 'obese' (World Health Organization, 2015). While there are many different means to measure body composition, body mass index (BMI) is currently what most organizations and healthcare professionals are using to track overweight and obesity rates. BMI is defined as an individual's weight (kg) divided by their height (m) squared (kg/m^2). Being overweight or obese can increase an individual's risk of suffering from a number of chronic diseases such as diabetes, cardiovascular diseases such as heart disease and stroke, musculoskeletal disorders such as osteoarthritis, and some cancers (endometrial, breast, and colon) (American College of Sports Medicine, 2011; WHO, 2015).

Obesity is a preventable disease that can be combatted in a number of ways, one of which is adequate energy expenditure through exercise. The American College of Sports Medicine (ACSM) (2011) recommends that adults (>18 years of age) perform 150-250 min a week (at least 1000 kcals) of moderate-intensity physical activity to prevent weight gain. Modest weight loss can be achieved through 150-250 min a week of moderate-intensity physical activity (about 3500 kcals per week), but greater amounts (>250 min) have provided significant weight loss (ACSM, 2011). Combing increased caloric expenditure through exercise and decreased caloric intake through diet is the best way to achieve weight maintenance and weight loss. While exercise rates in the United States are slowly climbing, the Centers for Disease Control and Prevention and U.S. Department of Health and Human Services (2014) found that only 20.8% of adults (>18 years of age) met the guidelines for both aerobic and muscle strengthening activities. This is noted by researchers as one of the contributing factors to the United States' staggering overweight and obesity statistics (CDC & HHS, 2015).

Statement of the Problem

A lack of time has long been cited as the main deterrent to exercise (Grubbs & Carter, 2002; Stutts, 2002; Trost et al., 2002; Kimm et al., 2006). CWT allows individuals to complete a large amount of work in a relatively short period of time. With the increased popularity of programs that utilize CWT as the only means of training, the body of knowledge pertaining to CWT needs to be increased. Federal guidelines and professional organizations such as ACSM have separate prescriptions for resistance training and aerobic training. Many individuals who partake in CWT utilize it as his or her only means to fulfill these exercise prescriptions (Waller, Miller & Hannon, 2011). Individuals are not only utilizing CWT to satisfy weekly exercise requirements, but also to increase caloric expenditure. Therefore, the purpose of this study was to compare the energy expenditure (EE) in total kcals and average rate of perceived exertion (RPE) values of a 20 min CWT protocol and a 20 min steady state aerobic protocol of equivalent intensity based on an individual's average HR during the CWT protocol

Null Hypotheses

H_{01}: There will be no significant difference between the energy expenditures of a 20 min CWT protocol and a 20 min steady state treadmill protocol of an equivalent intensity.

H_{02}: There will be no significant difference between the average RPE value of a 20 min CWT protocol and a 20 min steady state treadmill protocol of an equivalent intensity.

Operational Definitions

Circuit Weight Training (CWT) is defined as any training situation where participants move from exercise to exercise for a pre-determined amount of time or number of repetitions with limited or no rest between sets and circuits (Monteiro et. al., 2008; Ortego et al., 2009).

Delimitations

This study was delimited to healthy males between the ages of 18 - 35 years who were recruited from Eastern Washington University. Participants were physically active and partook in resistance training at least three times per week and had done so for a minimum of 6 months. Participants were also familiar with running on a treadmill. Participants were free of any upper or lower extremity injuries that may have hindered their ability to fully participate in the CWT activities that were particular to this study.

Limitations

This study was limited by the sample. The sample contained healthy adult males with resistance training and treadmill running experience. Different caloric expenditure and RPE values could be seen in different populations. The CWT protocol was also a limitation. All exercises were performed on machine weights in Eastern Washington

University's University Recreation Center. These selected exercises did not represent all exercises that could be utilized for CWT.

This study was limited by the Cosmed K4 b^2© portable respiratory gas analyzer. It limited the exercises selected to those that do not require body inversion or excessive jostling of the head and neck.

Assumptions

It was assumed that all participants abided by the procedures of this study including limiting physical activity to only the CWT protocol and the steady state aerobic protocol on the days of testing. It was also assumed that all participants were entirely honest about his past medical history, as well as his resistance and aerobic activity participation history.

Significance of Study

While research has determined that CWT and steady state aerobic training each exhibit physiological benefits, research comparing energy expenditures between similar intensities and duration of each mode is lacking. With fitness programs such as CrossFit™ becoming increasingly popular, it is important that such research is completed. Also, individuals frequently cite a lack of time as a barrier to exercise adherence. Understanding if either form of exercise results in greater caloric expenditure would enable those with weight loss goals to make more informed decisions.

Chapter 2

Review of Literature

Introduction

The purpose of this study was to compare the energy expenditures (EE) in total kcals and average RPE values of a 20 min CWT protocol and a 20 min steady state aerobic protocol of equivalent intensity based on a participant's average heart rate during the CWT protocol. In this chapter, CWT will be explored in depth with an emphasis on energy expenditure (EE), heart rate (HR), and excess post-exercise oxygen consumption (EPOC).

Circuit Weight Training

In the late 1970s, CWT entered the fitness industry and its popularity rose due to the increase not only in gym attendance, but also the use of strength equipment as well. Gettman, Ayres, Pollock, and Jackson (1978) first defined CWT as resistance training with lighter resistances (40-60% 1 Repetition Max (RM)) and little to no rest periods between exercises. In 1997, Kraemer redefined CWT as a predetermined set of exercises (stations) completed for a certain period of time or for 10 - 15 repetitions with 15 - 30 s of rest. Each circuit can be repeated if necessary. The modern definition of CWT has been re-shaped by the growing number of individuals who partake in group exercise classes that utilize CWT with free weights. CWT is currently defined as any training situation where participants move from exercise to exercise, performing work for a predetermined amount of time or number of repetitions, with limited rest (usually none) between sets and circuits (Monteiro et al., 2006; Ortego et. al., 2009). Today, CWT can also be further broken down into two groups. Traditional CWT utilizes resistance-training activities with a predetermined rest to work ratio (Garbutt et al., 1994; Gettman et al., 1980; Kaikkonen et al., 2000; Paoli et al., 2010; Wilmore et al., 1978). Aerobic CWT uses aerobic activities in place of rest periods (Abel et al., 2011; Mosher et al., 1994). Aerobic CWT has been used to combat the lack of cardiovascular activity during traditional CWT (Gettman, Ward & Hagman, 1982).

Many individuals utilize CWT because of its ability to train simultaneously several fitness components including muscular strength, muscular endurance, and cardiorespiratory endurance (O'Shea, 1987; Simonson, 2010; Wilmore et al., 1978); however, circuits can be altered to emphasize one fitness component over another. There is little dispute that aerobic CWT and traditional CWT both improve muscular strength and body composition values. After completing 20 weeks of traditional CWT, dynamic strength, assessed by 1RM, was found to improve by 42% - 56% in a seated leg press (Gettman, Ayres, Pollock & Jackson, 1978). Similar findings were depicted in a study by Gettman, Ward, and Hagan (1982) in which they examined a 12-week traditional CWT protocol in combination with a running program. Both groups that utilized CWT depicted increases to participants' muscular strength and $VO_{2\ max}$ by 17% and 12%, respectively, while body fat decreased ~3%. Traditional CWT alone was found to significantly increase muscular strength and power as compared to traditional CWT combined with endurance training in healthy male physical education students (Chtara et al., 2008). A decrease in body fat percent was seen as well in all three conditions that utilized CWT.

A circuit-training format has also been found to enhance sprint performance and anaerobic endurance in healthy males (Taskin, 2009). After completing 10 weeks of traditional circuit training, 100-m sprint times were significantly decreased in healthy male physical education students. They also depicted improvements in anaerobic endurance (Taskin, 2009).

Energy Expenditure. Currently, ACSM recommends that healthy adults participate in aerobic activity of moderate-intensity (40-60% of Heart Rate Reserve (HRR), $VO_{2\ max}$) for at least 30 min five days per week or 20 min or more of vigorous activity (>60% HRR, $VO_{2\ max}$) 3 days per week. ACSM also recommends resistance training be completed a minimum of two non-consecutive days per week for all major muscle groups. A healthy adult should complete at least 8 - 12 repetitions and an older or frail individual should complete 10 - 15 repetitions with body weight or a low weight as their resistance. Programs should utilize 8 - 10 exercises to target all major muscle groups (ACSM, 2011). ACSM also states that individuals should accumulate physical activity that results in the EE of at least 1000 kcals per week to prevent weight gain. If an individual fails to accumulate EE of 1000 kcals, but meets the weekly exercise guidelines, ACSM does not specify whether additional EE should be obtained from a certain mode of exercise (aerobic or resistance). This allows for an individual to choose which form of exercise they wish to partake in to obtain additional EE.

The nature of resistance exercises makes it difficult to measure EE during training sessions. Equipment utilized for measurements of EE can hinder an individual's ability to perform certain resistance training exercises. EE values during exercise are commonly obtained by means of indirect calorimetry. Indirect calorimetry measures O_2 consumption and CO_2 production, which are directly related to the body's EE (Ferrannini, 1988). During exercise, breath-by-breath measurements are taken by way of a facemask with a unidirectional turbine (Haugen et al., 2007).

EE during CWT has long been debated. Because CWT requires an individual to complete several different resistance-training activities, EE has been found to differ circuit to circuit. Using the Cosmed K4 b^2© to calculate EE values, Aniceto et al. (2013) compared the EE of a traditional CWT program and a traditional weight training format in ten recreationally-trained males. Each of the formats included the following machine exercises: bench press, leg press, seated row, leg curl, triceps pulley, leg extension, biceps curl, and adductor chair. Both programs were conducted at 60% 1RM using a standardized cadence of 1 sec for the eccentric phase and 1 sec for the concentric phase and with 60 s of recovery. In the traditional weight-training program, 3 sets of each exercise were completed before changing exercises. During the CWT method, participants rotated through exercises that utilized different body segments. Total EE were similar between the two conditions; however, estimated anaerobic EE was greater in the traditional weight-training format.

EE during moderate resistance (5.9 kg load for females and 10.5 kg load for males) traditional CWT was found to be significant as compared to low resistance (1.4 kg for females and males) by Beckham and Earnest (2000); however, intensity, as expressed by oxygen uptake, was well below ACSM guidelines. The average oxygen uptake was 32% VO_{2max}, well below the 50% VO_{2max} recommendation. This population was comprised of males and females aged 19 - 31 years. The Bruce Protocol was used to determine VO_{2max} and oxygen consumption was recorded using a KB1-C Ambulatory Metabolic Measurement System (Aerosport, Ann Arbor, MI). HR values fell within the recommended guidelines for activity (60% HR_{max}). Similar findings were depicted in a study by Monteiro et al. (2008) in a population of recreationally trained males and females 18 - 35 years of age. CWT (60 s of a resistance training activity) and combined CWT (30 s of a resistance training activity and 30 s of treadmill running) sessions failed to elicit VO_{2max} values that were within ACSM guidelines, but $\%HR_{max}$ values were within the recommended range.

In an attempt to quantify EE based on exercise selection, Vezina et al. (2014) evaluated actual EE by means of indirect calorimetry during four different activities (push-ups, curl-ups, pull-ups, and lunges) commonly utilized during CWT. Two different methods of estimating EE were then utilized to estimate EE during the 4 exercises: the traditional method, which estimates EE by calculating the average oxygen consumption recorded during each activity and the nontraditional method, which estimates EE by calculating the average oxygen consumption recorded during the recovery period following the exercise. Values that were acquired by the nontraditional method were significantly higher for all 4 activities; however this was not the case when using the traditional method, which underestimated EE values. This study concluded that methods individuals utilize to estimate EE may significantly affect EE estimates. The study within this thesis utilized a traditional method of calculating EE.

In an aim to determine a proper way to predict EE during CWT for women and men, Lozano et al (2010) examined a single traditional CWT protocol performed at 40%, 50%, 60%, 70%, 80%, and 90% of each individual's 15RM. The CWT protocol included the following exercises completed on machines: a sitting bench press, leg press, latissimus pull down, shoulder press, hamstring curl, biceps curl, and triceps cable push downs. EE was measured on a breath-by-breath basis (Jaeger Oxycon Mobile®, Viasys Healthcare, Germany). Men were found to obtain higher levels of EE (6.51 ± 0.72 kcal *

min^{-1}) than females during CWT at all six intensities; however the EE of women (3.96 ± 0.43 kcal * min^{-1}) tended to be more related to the intensity as it was progressively increased. Ortego et al. (2009) suggested that differences between the genders could be directly related to the load to muscle mass ratio, sex hormone levels, and stroke volume. This is similar to previous studies that indicated differences between sexes in terms of EE during resistance training (Byrne et. al, 2006; Castellani et al., 2006; Hoyt at al., 2006; Kuo et al, 2005; Papazoglou et al, 2006; Venables et al., 2005).

Heart Rate. Heart rate (HR) during CWT can be a very important training variable for individuals looking to utilize CWT as a means of training. HR has long been considered a reliable means of determining aerobic exercise intensity because of a direct linear relationship between oxygen consumption (O_2) and HR. Heart rate response to different means of CWT was examined by Skidmore, Jones, Blegen & Matthews (2012). Traditional CWT, aerobic CWT, and combined CWT interval training were examined. Heart rate response was found to be the highest during combined CWT interval training (83.51 ± 1.18 beats * min^{-1}) and lowest during traditional CWT (70.42 ± 1.67 beats * min^{-1}); however, caution should be used when using HR to determine intensity during CWT.

While HR values may be within the recommended range for developing cardiovascular fitness, oxygen consumption may not follow a linear path in CWT, especially at loads above 70% 1RM (Collins, Cureton, Hill & Ray, 1990; Gotshalk, Berger & Kraemer, 2004). This differs from the findings of Alcaraz, Sanchez-Lorente & Blazevich (2008) who found that HR values fell within ACSM guidelines for aerobic activity for active males during a traditional CWT protocol performed at loads greater than 75-100% 1RM values. Workloads above 75% of 1RM are not frequently used and have not been heavily researched. Such outcomes may differ depending on the population. Low resistance CWT with moderately hard HR level (70-80% HR_{max}) has depicted effects comparable to a bout of endurance training of equivalent intensity on cardiovascular fitness in sedentary adults (Kaikkonen et al., 2000). Gotshalk, Berger & Kraemer (2004) found that HR values were higher (~165 bpm) during CWT than during treadmill running (150 bpm) at the same 50% VO_{2max}. This study utilized a circuit with 10 machine weight exercises. It was completed 4.6 times for a total duration of 16 min and 36 s. HR values during the CWT protocol in this study were greater than 70% HR_{max} for 16.6 min and greater than 80% HR_{max} for the last 12 min. This was further explored by Palio et. al (2010) where HR response to three modes of training were examined. The three modes of training were endurance training, low intensity circuit training (4 min at 66% HR_{max}), and high intensity circuit training (3 min at 66% HR_{max} and 1 min at 85% HR_{max}). This study demonstrated that high intensity CWT resulted in the greatest improvement in body composition, blood lactate threshold, and maximal muscular strength and, therefore, may yield more benefits than other forms of CWT. However, this study was a training study that utilized 3 50-min exercise sessions per week over a 12-week span. The study conducted in this thesis was an intervention and did not utilize training over time.

Excess Post-Exercise Oxygen Consumption. Excess post-exercise oxygen consumption (EPOC) is defined as the oxygen uptake above resting values used to restore the body to the pre-exercise condition (Baechle & Earle, 2008). The effect of resistance training on EE during EPOC has long been studied (Binzen, Swan & Manore, 2001;

Burleson et al., 1998; Crommett & Kinzey, 2004; Elliot, Goldberg & Kuehl, 1992; Haddock & Wilkin, 2006; Hunter, Seelhorst & Synder, 2003; Hunter et al., 2000; Jamurtas et al., 2004; Melanson et al, 2002; Melby, Tincknell & Schmidt, 1992; Olds & Abernethy, 1993; Schuenke & Mikat, 2002; Thornton & Potteiger, 2002). EPOC following resistance training may require 60 min or more to return to pre-exercise levels. This appears to be directly related to the intensity of the resistance training (Haltom et al., 1999; Laforgia, Withers & Gore, 2006); however, EPOC duration and the factors contributing to its intensity and duration are topics of debate amongst researchers. The magnitude and duration of EPOC have been depicted as essential components of a successful weight management program (Schuenke, Mikat & McBride, 2002).

EPOC values were very similar in a study by Lavinas Da Silva, Brentano & Kruel (2010) that utilized two different methods of strength training on non-strength-trained women (n=8). The two methods that were utilized were circuit training and pre-exhaustion. The study found that the magnitude of EPOC is not due to exercise order, but the absence of recovery periods between sets and exercises in resistance training. This appears to promote an increase in EPOC to the levels found in training sessions at higher 1RM percentages. This is consistent with a study by Lavinas Da Silva, Brentano & Kruel (2010) who also found that exercise order did not factor into EPOC values.

Thornton and Potteiger (2002) utilized two different exercise intensities to explore the relationship between EPOC and exercise intensity. Fourteen trained females completed the same CWT protocol at 45% and 85% of their 8RM. While exercise VO_2 was not significantly different between protocols, EPOC magnitude and volume were higher for the 85% protocol than the 45% protocol. Similar findings were noted by

Abboud, Greer, Campbell & Panton (2013) in trained men. Because of the training history of the population, the training stimulus required to increase EPOC needed to be much more intense (85% 1RM) than used in previous research. However, these findings differ from that of Olds and Abernathy (1993) who found no significant difference in EPOC resulting from heavy (75% 1RM) and light (60% 1RM) resistance exercise in trained males.

When compared to standard resistance training, CWT has been found to elicit a higher EPOC value and last for longer (Murphy & Schwarzkopf, 1992; Lavinas Da Silva, Brentano & Kruel, 2010). While the length of time EPOC occurs is debated, this can still be very important for an individual utilizing CWT as a means of weight loss. If one is looking for a greater caloric deficit, CWT may be a better option than traditional resistance training.

Conclusion

CWT has become a popular means of exercising and maintaining one’s physical fitness; however, there is still a lack of research regarding EE during CWT. The purpose of this study was to compare the EE in total kcals and average RPE values of a 20 min CWT protocol and a 20 min steady state aerobic protocol of equivalent intensity based on an individual’s average HR during the CWT protocol. In this chapter, circuit weight training (CWT) was described in depth an examination of its effect on energy expenditure (EE), heart rate (HR), and excess post-exercise oxygen consumption (EPOC)

Chapter 3

Methods

The purpose of this study was to compare EE in total kcals and average RPE values of a 20 min CWT protocol and a 20 min steady state aerobic protocol of equivalent intensity based on an individual's average HR during the CWT protocol.

Participant Selection

Participant recruitment was performed through verbal recruitment of male students in several classrooms in the Physical Education Building at Eastern Washington University. Participants were between the ages 18 - 25 years. To avoid the potential confounding effects of sex on EE, only males were utilized. The participants were required to have at least 6 months of resistance training experience (>3 sessions per week) and treadmill experience. Exclusion criteria included a history of significant injury or illness that would hinder their ability to fully participate, inability to wear a facemask during exercise, and the need to modify exercises selected for use in the study. Based on similar previous research, the target sample size for this investigation was 12 (Gotshalk, Berger & Kraemer, 2004; Vezina et. al, 2014).

Instrumentation

The Cosmed K4 b^2© (Rome, Italy) portable respiratory gas analyzer has been demonstrated to be a valid and reliable instrument used to indirectly assess caloric expenditure during exercise (Howe et al., 2014). The calibration and pre-testing procedures were followed as outlined by the manufacturer before each individual testing session. Environmental conditions were controlled and relative humidity was kept between 40 and 60%. HR values were obtained using a FT1 Polar heart rate monitor

(Polar Electro, Kempele, Finland). HR values were stored within the K4 b^2© along with all other testing variables. The K4 b^2© was set at a sampling rate of 2 sec for both testing variables: HR and total EE.

All CWT exercises were conducted on Matrix Aura Series Single-Station Machines (Johnson Health Tech, Taichung, Taiwan). The circuit included: a chest press, leg press, latissimus pull down, shoulder press, hamstring curl, leg extension, assisted pull-up, pec fly, seated row, and back extension. Steady state aerobic activity was conducted on a T7xi Matrix Treadmill (Johnson Health Tech, Taichung, Taiwan).

Procedures

Prior to participant recruitment, approval from the Eastern Washington University Institutional Review Board for Human Subjects Research was obtained (Appendix A). Participant recruitment began by inviting individuals to one of four informational sessions. During these sessions, the principal investigator read from a script (Appendix B) and answered any questions. After each presentation, interested individuals completed a standard health screening questionnaire (Appendix C) with one additional question pertaining to the usage of medications affecting heart rate. If an individual answered 'yes' to any question, they were excluded from participation. Secondly, individuals were asked about their participation history in resistance training and their familiarity with treadmills. Those who met all criteria and chose to participate were presented with an informed consent (Appendix D) that described all of the procedures of the study as well as the risks associated with their participation, the voluntary nature of the study, and their right to withdraw at any time.

Participants were allowed to continue their normal exercise routine, but they were instructed to not perform any exhaustive exercise the day before or day of the testing sessions. Participants were instructed to not consume any caffeine 24 hours before any testing sessions. Testing occurred across three different training sessions. The first day included familiarization with the equipment and Modified Borg RPE scale (Appendix E) as well as 10RM testing for all CWT exercises. The CWT protocol was completed on the second testing day. The steady state aerobic activity was administered on the third day. Testing took place at Eastern Washington University's Student Recreation Fitness Center with prior approval by Fitness Center Director.

The first day began with anthropometric measurements that included height and weight. Height (cm) was obtained through the use of a pocket stadiometer (Harpenden, Hotain Ltd, UK). Each participant's weight (kg) was obtained using a mechanical scale (Tanita, Japan). The 0 - 10 Borg RPE scale was then described to each participant, as well as the proper way in which it should be utilized during exercise (Borg, 1998).

Familiarization with the CWT machines took place next. Each participant had time to become aquatinted with and fitted for each machine. Participants were then instructed how to properly perform each lift and given an opportunity to perform each. Individuals were then familiarized in the proper utilization of the cadence of 1 s up and 1 s down during the CWT protocol. Next, estimated 1RM values were obtained for each lift. The protocol for obtaining estimated 1RM values by way of a 10RM load as outlined by Brzycki (1993) was utilized for this study. Participants began with a warm-up of 5 -10 repetitions at a light resistance. After a 1 min rest period, a warm-up of 5 - 10 repetitions at a moderate resistance was completed with a 3 min rest period following. Ten RM testing began following this rest period. A load was placed on each machine that the participant felt he was able to lift 10 times without failure in technique or fatigue prior to 10 repetitions. If the participant was able to do so, another trial was completed after a 3 min rest period. Load increases were between 5 – 10 pounds for upper body lifts and 15 – 20 pounds for lower body lifts. It has been recommended that strength testing be completed within 3 - 5 attempts to avoid fatigue (Baechle & Earle, 2008). Each participant was given 2 - 4 min of rest between each of the 10 exercises. At the completion of 1RM testing, the participant completed a five-min cool down on a T7xi Matrix Treadmill (Johnson Health Tech, Taichung, Taiwan).

Prior to the second day of testing, the researcher calculated each participant's estimated 1RM value for each lift by utilizing the multiple RM table for predicting 1RM values (Brzycki, 1993). Previous research has used an intensity of 40% 1RM for CWT (Gotshalk, Berger & Kraemer, 2004); thus, 40% values were calculated. Each machine was set to these loads before beginning the CWT protocol.

To begin the second day of testing, each participant was fitted for the K4 b^2© and a Polar heart rate monitor (Polar Electro, Kempele, Finland). Resting HR was obtained for each participant before beginning the warm-up for the CWT protocol. Each participant was instructed to be seated for 5 min with limited movement. At the conclusion of the 5 min period, the HR value was recorded. To begin the CWT protocol, the participant began with a 5 min warm-up on a treadmill. Participants were instructed to select a speed that he would normally utilize to warm-up for a resistance training session. No data was recorded during this time. Once each participant completed the warm-up, he was directed over to first CWT station. At this time, any questions were addressed or adjustments to equipment were made. This time was not longer than 2 min with any participant. The participant then completed the CWT protocol (Table 1). The CWT protocol consisted of 10 stations. Each station consisted of 15 repetitions performed at a cadence of 60 beats per min or 1 s for the concentric and eccentric phases of the lift, resulting in a total of 30 s of work per station. The circuit was completed three times, which required approximately 20 min. Transit between stations was completed at a brisk walking pace to limit rest; however, as this varied across participants, the CWT protocol was concluded at different stations. The average completion time for the circuit was 19 min and 49 s. Three participants failed to finish the circuit in the 20 min time frame. RPE values were taken at the end of every 4^{th} station throughout the protocol and at the completion of the protocol. Values were obtained at the following stations because of this pattern: shoulder press, pec fly, leg press, leg extension, and back extension. Improper utilization of the RPE scale and the standard metronome were combated by proper familiarization prior to the administration of the protocol. HR was monitored throughout the CWT protocol by the Polar heart rate monitor whose data was recorded by the K4 b^2©. Once the participant reached the end of the CWT protocol, they completed an active 5 min cool down, which consisted of walking on the treadmill. No data was collected during this part of the protocol and the K4 b^2© was removed.

The third day of testing occurred between 2 - 5 days after the second bout of testing. Each participant was once again fitted for the K4 b^2© and a Polar heart rate monitor (Polar Electro, Kempele, Finland). Prior to beginning the steady state aerobic activity, the participants were reminded to limit excessive movement of the head and neck. The participant began by jogging at a self-selected speed on a T7xi Matrix

Treadmill (Johnson Health Tech, Taichung, Taiwan). The speed was increased 0.2 mph every 60-120 s until the average HR from the CWT protocol was elicited and maintained. The time to reach and maintain the average HR was different for each participant and was not recorded. Once the average HR was maintained for 2 min, data collection began. The participant then completed 20 min of jogging at this intensity. Due to a fluctuation in HR, some participants required the speed to be decreased or increased after the protocol had begun. RPE values were obtained every two min. Average HR was determined by the K4 b^2© at the conclusion of the run. Following the completion of the steady state exercise, the participant completed a 5 min active cool down.

Table 1

CWT Protocol

Order	Exercise
1	Chest Press
2	Leg Press
3	Latissimus Pull Down
4	Shoulder Press
5	Hamstring Curl
6	Leg Extension
7	Assisted Pull-Up
8	Pec Fly
9	Seated Row
10	Back Extension

Statistical Analysis

Descriptive statistics were calculated for age, height, weight, resting HR, energy expenditure, and RPE. Inferential statistics were calculated using IBM SPSS Statistics for Windows Version 21.0 (IBM Corp., Armonk, NY). Paired samples t-tests were utilized to determine if there was a significant difference in the total kcals expended between equivalent bouts of CWT and steady state aerobic activity and if there was a significant difference in average RPE values between equivalent bouts of CWT and steady state aerobic activity. The alpha level for this analysis was set at $p < 0.05$.

Chapter 4

Results

Participants

Based on similar previously conducted studies, the target sample for this investigation was 12 recreationally trained college-aged males (Gotshalk, Berger & Kraemer, 2004; Vezina et. al, 2014). Thirteen participants were recruited, but one was excluded for medication reasons. While the study was in progress, the leg press machine broke, sometime between when the ninth and tenth participant had completed their CWT protocol so the sample size was reduced to nine. All statistical analyses were conducted using a sample size of nine. No participants chose to withdraw during the course of the study. Demographic information of the sample population is provided in Table 2.

Energy Expenditure

A paired samples t-test revealed a significant difference in kcals expended between the two protocols ($t(8) = -7.154$, $p = <.001$). Twenty min of CWT resulted in the expenditure of 168.2 ± 16.4 kcals while the steady state aerobic activity resulted in the expenditure of 244.2 ± 44.8 kcals. Steady state aerobic activity resulted in the expenditure of ~37% more kcals than CWT [(244-168) / (244+168) /2]. Total EE values for the CWT protocol and steady state aerobic activity for each participant are provided in Figure 1.

Table 2

Participant Demographics

Characteristic	Mean ± Standard Deviation
Height (cm)	176.8 ± 5
Weight (kg)	83 ± 14.1
Age (years)	22.1 ± 1.9
Resting HR (bpm)	65.8 ± 6.7

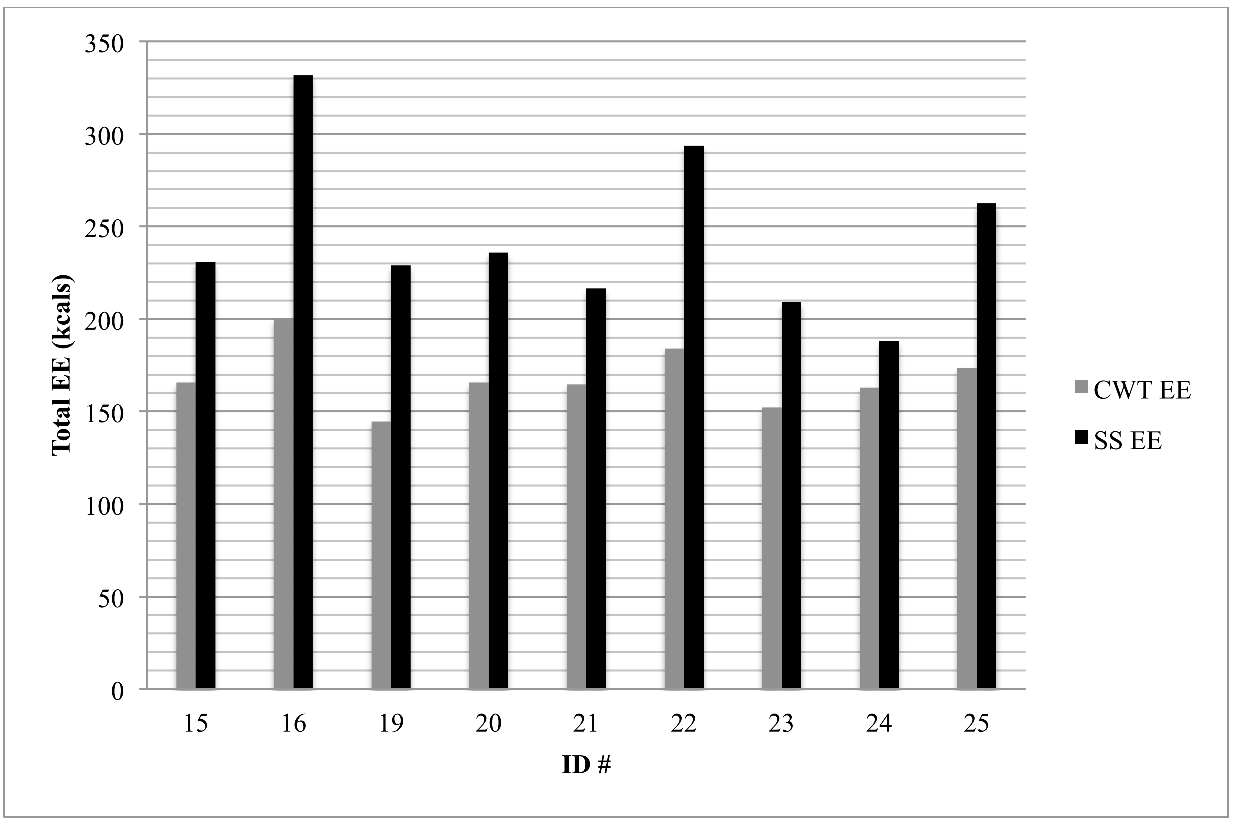

Figure 1. CWT EE vs. Steady State Aerobic EE for each participant n = 9

Rate of Perceived Exertion

RPE was taken every 4 stations during the CWT protocol and every 2 min for the steady state aerobic protocol. A paired samples t-test revealed a significant difference in RPE values between the two protocols ($t(8) = 6.791$, $p = <.001$). Average RPE values during the CWT protocol was 6 ± 1.1 while average RPE for steady state aerobic activity was $4.1 \pm .6$. RPE values compared to total EE for both the CWT protocol and steady state aerobic activity for each participant are displayed in Figure 2.

Heart Rate

Average heart rates were calculated for the CWT protocol and steady state aerobic activity. The average HR for the CWT protocol was used to establish the intensity of the steady state aerobic activity for each participant. The average HR for the steady state aerobic activity was no more than ± 5 bpm of the average HR of the CWT protocol. The average intensity that the CWT protocol elicited was 58%HRR.

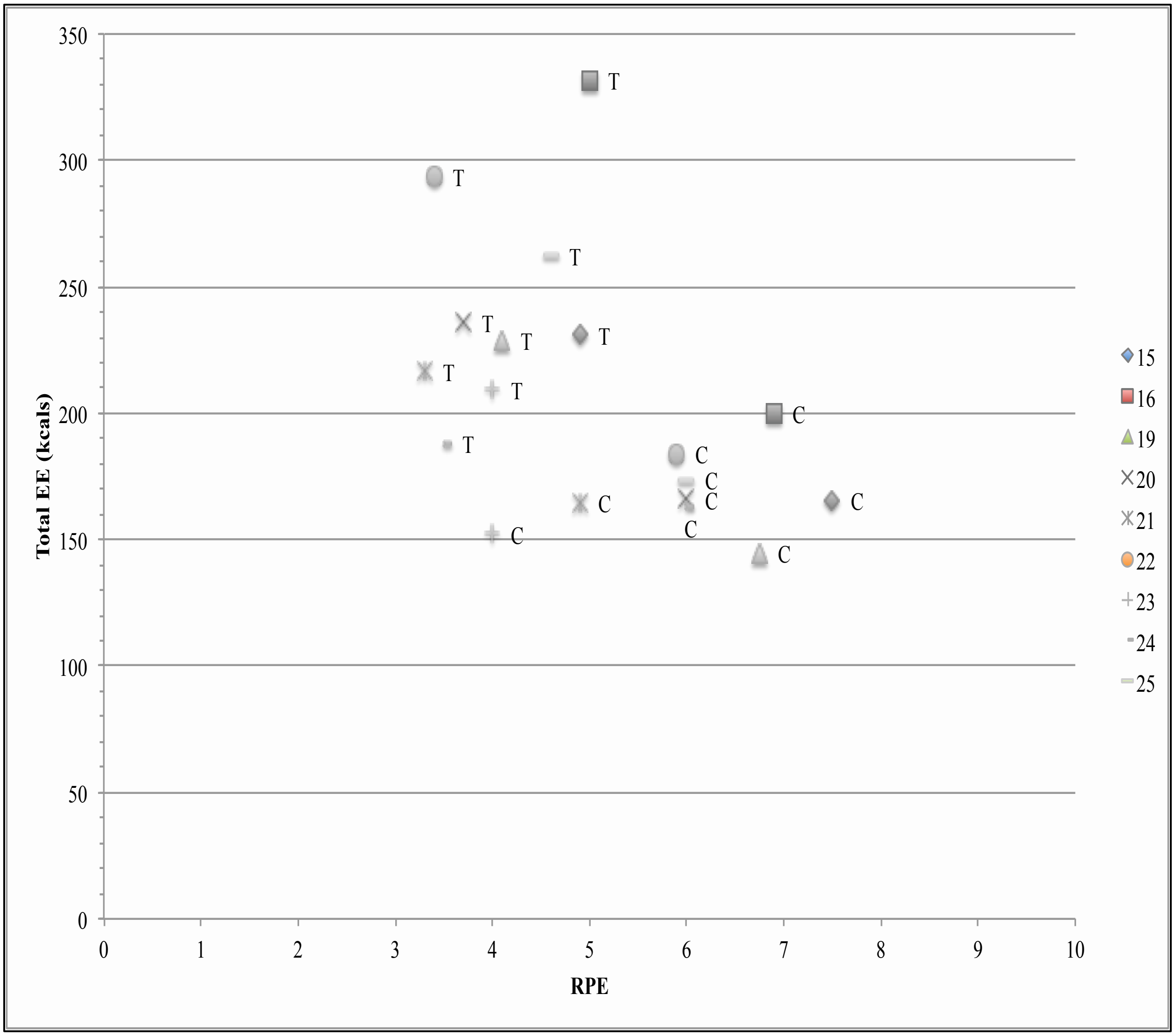

Figure 2. RPE vs. CWT EE and Steady State Aerobic EE for each participant (C = CWT, T = Steady State Aerobic Activity) n = 9

Chapter 5

Discussion

This study compared EE in total kcals and RPE values of CWT exercise and aerobic exercise performed at equivalent intensities and durations. The dependent variables, EE and RPE, were evaluated following the experimental interventions, which consisted of a single bout of CWT and a single bout of steady state aerobic training.

Oxygen Consumption and Heart Rate Response

The linear relationship between oxygen consumption and HR during steady state aerobic activity has long been established. While the average HR for both conditions was within ±5 bpm of one another, HR range was greater during the CWT protocol. Participants' HR values for the CWT protocol had a much higher variability (SD ± 16 bpm) as opposed to the steady state aerobic activity (SD ± 3.9 bpm). These findings are consistent with previous studies examining HR during CWT and steady state aerobic activity of similar intensities (Hedman, 1957; Collins, Cureton, Hill & Ray, 1990, Gotshalk, Berger & Kraemer, 2004).

All participants depicted an increase in HR over the course of the 20-min CWT protocol, but oxygen consumption remained fairly consistent, which has been depicted in previous research (Faria, 1970; Gettman & Pollock, 1981; Gotshalk, Berger & Kraemer, 2004). This means that if an individual utilizes just HR to estimate caloric deficit during a bout of CWT, their calculation may overestimate their actual caloric expenditure. This was indicated by Gotshalk, Berger & Kraemer (2004) as well. HR values in their study were adequate for improvements in cardiovascular endurance, but oxygen consumption was not. The average exercise intensity for participants in this thesis was 58%HRR, which falls within the ACSM recommendations for cardiovascular improvements.

Consistent with research, HR and oxygen consumption were linearly related during the steady state aerobic protocol, which is consistent with research (Astrand & Rodahl, 1986; Gettman & Pollock, 1981; Nagle & Irmin, 1960). Oxygen uptake increased during the warm-up. Once the oxygen demand was equivalent with the oxygen consumption, steady state, as indicated by HR, was achieved and data collection began. Twenty min of steady state aerobic activity resulted in the expenditure of significantly more calories than 20 min of CWT. EE was greater for every participant during the steady state aerobic activity than the CWT protocol.

During the CWT protocol, 25% of the exercises were single joint exercises, which resulted in a smaller muscle mass available for recruitment, while steady state aerobic training utilized larger muscle groups and, therefore, larger muscle mass. Astrand and Saltin (1961) and Hedman (1957) noted that when smaller muscle groups were recruited and fatigued during heavy resistance exercise, individuals were working at levels between 70-80% of their VO_{2max}; however, at these levels, HR values were above maximal levels and lactate concentrations were very high. While blood lactate values were not recorded in this study, it is easy to assume that values were greater during the CWT protocol due to the utilization of fast twitch muscle fibers. This assumption as well as the fact that HR response and variability was higher during CWT would indicate a greater anaerobic response during CWT than steady state aerobic activity.

The CWT protocol utilized in this study would fall into a similar intensity category as that of Paoli et. al (2010) who compared the effects of endurance training

(50%HRR), low intensity traditional CWT (65%HRR), and high intensity traditional CWT (3 min at 50%HRR and 1 min at 75%HRR) against one another and found that while all were beneficial to overall improvement in health in untrained individuals, high intensity CWT resulted in significant improvements in maximal strength and body composition (6RM testing and skinfold measurements) versus the other two interventions. Even though EE values were higher for steady state aerobic activity in the current study, the overall health benefits (e.g. increase in muscular strength, increase in muscular endurance) of CWT may offset this difference. If caloric expenditure is the ultimate goal, results of this study indicate the superiority of steady state aerobic activity; however, CWT increases skeletal muscle mass, a goal that cannot be accomplished with aerobic exercise. A comprehensive fitness program should include both types of exercise.

Exercise Intensity and RPE

The CWT intensity for each individual was controlled by utilizing 40% of each individual's predicted 1RM value determined by10RM testing for each lift. While previous studies have utilized 1RM testing (Gotshalk, Berger & Kraemer, 2004), 10RM testing has been found to be more accurate and appropriate for maximal testing that utilizes machine weights (Baechle & Earle, 2008). This selected intensity for this study resulted in varying responses from study participants. For six of the participants, 40% of their predicted 1RM was appropriate and allowed them finish the circuit in the 20 min time frame. For three of the participants, the load was too extreme, and they were unable to finish. Local fatigue may be to blame for the varying intensities among participants. While every participant was required to have at least 6 months of resistance training experience and partake in resistance training at least 3 times per week, neither mode of resistance training or specific muscles regularly trained were considered. Participants noted during the CWT protocol that two of the exercises (shoulder press and the assisted pull-up) were particularly difficult during the latter rounds of the circuit. An elevation in HR was depicted during these exercises in every participant. If participants were not completing any resistance training specific to these exercises or any of the others, those muscle groups may have been untrained and, therefore, produced an increase in local fatigue that manifested in increased RPE.

HR values and RPE values were noted to have relatively similar curves in a study by Skidmore, Jones, Blegen & Matthews (2012); however, previous research has indicated that HR may not be the best indicator of cardiovascular load in resistance training (Petersen et al., 1988). In the current study, RPE values were higher during the CWT protocol than the steady state aerobic activity. During the CWT protocol, RPE and HR values had greater variation as well; however, there were no markers placed in the energy expenditure data to indicate which station the participant was at during a set data point so there is no way of knowing the HR value at the exact time RPE was recorded. Even though RPE values and HR values had greater variation during the CWT protocol, EE values were significantly higher during the steady state aerobic activity. This may suggest that RPE is not a great indicator of overall EE; however, participants felt they were working harder during the CWT protocol much like individuals partaking in CWT outside of this study. RPE was concluded to be a valid means of controlling effort during CWT by Aniceto et al. (2015); however, EE was not explored in this study.

Limitations

This study was unique in the fact that it compared EE from equivalent bouts of CWT and treadmill running based solely on HR. It was also one of the few studies to utilize indirect calorimetry by means of the K4 b^2© during CWT. While aerobic EE was accounted for by means of the K4 b^2©, anaerobic EE was not accounted for in this study. It is assumed that anaerobic energy systems would have accounted for some amount of the overall EE during CWT; however, participants were working at 58%HRR (<60% VO_{2max}), which falls below the lactate threshold for trained individuals (between 70% VO_{2max} and 80% VO_{2max}) so anaerobic EE would have been minimal.

Other than eliminating caffeine intake 24 hr prior to testing, dietary limitations were not placed on the participants. A participant's dietary choices prior to testing would have influenced his body's fuel use. Dynamic strength testing did not utilize the standardized cadence that was implemented during the CWT protocol and this may have affected the perception of effort as well. The use of average HR as the sole indicator of exercise intensity for this study was a limitation. The area in which the study was conducted also posed a bit of a challenge. The EWU Recreation Center has limited space for all of its machine weights. While transit was limited between machines, this was a hard variable to control. Each individual had a different walking speed, which led to variability in transit time.

Future Research

Future research should utilize VO_{2max} testing to establish the aerobic capacity of each participant prior to partaking in the study. During CWT and treadmill running, intensity could then be monitored using both HR and O_2 consumption. Because CWT is such a unique form of exercise, individuals that have utilized CWT similar to the study protocol as a means of training should be used as the participant population. This will decrease any of the confounding effects of using individuals unfamiliar with CWT. Future research should also look into different training loads and their effects on a number of different variables including EPOC. Higher training loads have depicted greater EPOC values, which would lead to a greater caloric deficit over time (Haltom et al., 1999; Laforgia, Withers & Gore, 2006).

The most common way to determine exercise intensity in the general population is by measuring HR. While RPE and HR are correlated, EE values may not correlate to RPE and HR in CWT so each individual should be careful not to misinterpret his perception of how difficult his CWT protocol is with how many kcals he is burning.

Conclusion

CWT is currently at the forefront of the exercise industry. Many individuals are utilizing CWT as his or her only form of exercise and many have weight maintenance or weight loss as one of his or her main fitness goals. For individuals with the sole goal of weight loss, CWT only programs may not be appropriate. Individual goals and fitness assessments should be conducted prior to selecting a fitness program to ensure individuals are getting what he or she needs out of exercise. This study examined the EE and average RPE between equivalent bouts of CWT and steady state aerobic activity based on average HR. While this study indicated that EE is greater during steady state aerobic activity, the multiple fitness benefits associated with CWT may outweigh the decrease in EE. With most modern CWT regiments taking between 20 and 30 min, most individuals would not achieve EE values that result in weight loss during this time frame so steady state aerobic activity would be a much more beneficial use of time for individuals looking to solely lose weight.

Appendix A

Eastern Washington University Institutional Review Board for Human Subjects

Research Conditional Approval of Research

Eastern Washington University

Cheney and Spokane

MEMORANDUM

To:	Breann Booher, Department of Physical Education, Health and Recreation, 200 PEB
From:	Sarah A.C. Keller, Chair, Institutional Review Board
Date:	April 15, 2015
Subject:	Expedited Review of *Comparing Energy Expenditures Between A Circuit Weight Training Protocol and A Steady State Aerobic Activity* (HS-4779)

The Institutional Review Board for Human Subjects' Expedited Review Committee has reviewed your proposal to compare the energy expenditures of a 20-minute circuit weight training protocol and a 20-minute steady state aerobic protocol of an equivalent intensity.

The Expedited Review Committee has approved your application subject to the conditions noted below; a signed, approved copy of your application is enclosed.

Before you begin:

1. We will need a script that you can follow when you are orally recruiting people. This can just be a bulleted list and you don't have to read it them but it serves as a check list so that you are sure you say the following required pieces of information to each potential subject:
   - If they don't already know you then tell them who you are, your contact information, email and phone, and if you are recruiting off campus you should say you are at Eastern Washington University,
   - Describe the study,
   - Why you are doing it [i.e., in partial fulfillment of the requirements for your Masters degree],
   - Who besides you will have access to the raw data and who you will share the results with,
   - You must clearly state that participation is voluntary and confidential, and how you will maintain their confidentiality,
   - You must tell them that they may omit any demographic question(s) they choose not to answer,
   - They will have to fill out a health questionnaire to see if they meet the criteria before they may become a subject,
   - You must tell them that if they have any concerns about their rights as a participant in this research or any complaints they wish to make, they may contact Ruth Galm, Human Protections Administrator at Eastern Washington University (509-359-7971/6567) <rgalm@ewu.edu>.
2. The health screening should be done before they sign a consent form. If they do not qualify you should immediately give the screening instrument back to them and let

Department of Geography and Anthropology

MS-52, 103 Isle Hall • Cheney, Washington 99004 • (509) 359-2433 • Spokane – (509) 458-6213

Eastern Washington University is an equal opportunity, affirmative action institution.

them know they can't participate. If they do qualify, keep the screening form if they become a subject and return it to them if they do not.

3. You say that if the study is published you will not use their names; even if it isn't published you should never use their names or other identifiers because you have promised them confidentiality.
4. The consent form should either be on PEHR department letterhead or Dr. Brewer's letterhead. It shouldn't be on generic EWU letterhead.
5. Please print the consent form double-sided so that the information about the study is on the same piece of paper as the signatures.
6. There is a typo in the second paragraph of the consent form aquatinted rather than acquainted.
7. Please send me a memo addressing the above issues and any new or revised document(s). *Do not send me the whole application.*

Human subjects research approval granted by the IRB is good for one year from the date of approval, to April 15, 2016. If research is to continue, with no substantial changes, beyond that date, a renewal of IRB approval must be obtained prior to continuation of the project (contact OGRD for procedure). If, subsequent to initial approval, a research protocol requires minor changes, the OGRD should be notified of those changes. Any major departures from the original proposal must be approved by the appropriate review process before the protocol may be altered. A Change of Protocol application must be submitted to the IRB for any substantial change in the protocol. The Director, Grant and Research Development, or the Chair of the IRB will determine whether or not the research must then be resubmitted for approval.

If you have additional questions please contact me at 509-359-7039; fax 509-359-2474: email: skeller@ewu.edu. It would be helpful if you would refer to HS-4779 if there were further correspondence as we file everything under this number. Thank you.

C.Brewer
R.Galm
Graduate Office

Appendix B

Script for Thesis Participant Recruitment

1.) Introduction of Myself
  - Name including my affiliation with Eastern Washington University
  - Contact Information
2.) Describe of Study
  - Purpose
  - Procedures
  - Significance of the Study
  - Why I am Completing the Study
  - Data Collection Specifics
    - o Where Raw Data Will Be Kept
    - o Who Will Have Access To It
3.) Participation Specifics
  - Voluntary and Confidential
  - Choice to omit from any demographic questions
  - Health questionnaire è Subject
  - If they have any concerns about their rights as a participant in this research or any complaints they wish to make, they may contact Ruth Galm, Human Protections Administrator at Eastern Washington University (509) 359-7971 rgalm@ewu.edu

My name is Breann Booher, and I am a graduate student at EWU and employee at the URC. To fulfill requirements for my master's degree, I am conducting a research project. The purpose of the study is to see if a person expends more calories performing circuit weight training or treadmill exercise. CWT is often claimed to burn more calories than most types of aerobic exercise, and I am trying to determine if it actually does.

There are certain criteria for participation. If you are interested in volunteering, I can screen you for participation in just a few min.

The study will require 3 sessions of about 45 min each. The first is a familiarization and baseline testing session, and the next two consists of one CWT session and one treadmill running session. You do have to wear a facemask during the last two sessions. This allows me to determine calorie expenditure.

Your participation is totally voluntary, and you can discontinue your participation at any time. All data collected is confidential and protected, and only my research advisors will have access to it.

If you have questions about the study, you can contact me by e-mail at breannbooher@eagles.ewu.edu or by cell phone at 253-241-3835. If you have any concerns about your rights as a participant in this research, you may contact Ruth Galm, Human Protections Administrator at Eastern Washington University (509) 359-7971 or rgalm@ewu.edu.

Appendix C

Health Screening Questionnaire

EASTERN WASHINGTON UNIVERSITY

Department of Physical Education, Health and Recreation
200 PEB, Cheney, WA 99004-2476
425-577-1389

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HEALTH SCREENING QUESTIONNAIRE (HSQ)

Assess your health needs by marking all true statements.

Participants are required to answer the following questions. The questions were designed, in consultation with occupational health physicians, to identify individuals who may be at risk when participating in a controlled submaximal exercise protocol. The HSQ is not a medical examination. Any medical concerns you have that place you or your health at risk should be reviewed with your personal physician prior to participating in the study.

Check 'Yes' or 'No' in response to the following questions:

☐Y ☐N 1) During the past 12 months have you at any time (during physical activity or while resting) experienced pain, discomfort or pressure in your chest.

☐Y ☐N 2) During the past 12 months have you experienced difficulty breathing or shortness of breath, dizziness, fainting, or blackout?

☐Y ☐N 3) Do you have a blood pressure with systolic (top #) greater than 140 or diastolic (bottom #) greater than 90?

☐Y ☐N 4) Have you ever been diagnosed or treated for any heart disease, heart murmur, chest pain (angina), palpitations (irregular beat), or heart attack?

☐Y ☐N 5) Have you ever had heart surgery, angioplasty, or a pace maker, valve replacement, or heart transplant?

☐Y ☐N 6) Do you have a resting pulse greater than 100 beats per minute?

☐Y ☐N 7) Do you have any arthritis, back trouble, hip /knee/joint /pain, or any other bone or joint condition that could be aggravated or made worse by controlled maximal exercise testing?

☐Y ☐N 8) Do you have personal experience or doctor's advice of any other medical or physical reason that would prohibit you from participating in controlled maximal exercise testing?

☐Y ☐N 9) Has your personal physician recommended against participating in controlled maximal exercise testing because of asthma, diabetes, epilepsy or elevated cholesterol or a hernia?

Regardless whether you are exercising at Vigorous, Moderate or Light levels, a "Yes" answer requires a determination from your personal physician stating that you are able to participate. If you do not have a personal physician determination allowing you to participate in controlled maximal exercise testing, you will be excluded from the study.

NAME:____DATE______________________

Privacy Statement

The information obtained in the completion of this form is used to help determine whether an individual being considered for the study can participate in a manner that will not place the participant unduly at risk due to inadequate physical fitness and health. Its collection and use are covered under Privacy Act System of Records OPM/Govt-10 and are consistent with the provisions of 5 USC 552a (Privacy Act of 1974).

Paperwork Reduction Act Statement

According to the Paperwork Reduction Act of 1995, an agency may not conduct or sponsor, and a person is not required to respond to a collection of information unless it displays a valid OMB control number. The valid OMB control number for this information collection is 0596-0164. The time required to complete this information collection is estimated to average 5 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

Appendix D

Informed Consent Form

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Informed Consent For
Comparing Energy Expenditures Between A Circuit Weight Training Protocol and A Steady State Aerobic Activity

Principle Investigator

Breann M. Booher, Graduate Student, Eastern Washington University
Department of Physical Education, Health, and Recreation (PEHR)
breannbooher@eagles.ewu.edu, (253) 241-3835

Christi Brewer, PhD., CSCS, Professor, Eastern Washington University
Department of Physical Education, Health, and Recreation (PEHR)
christileigh@gmail.com, (509) 359-2485

Purpose and Benefits

The purpose of this study is to compare the energy expenditures of a twenty-minute circuit weight training protocol and a twenty-minute steady state aerobic protocol of equivalent intensities based on an individual's average heart rate during the circuit weight training protocol. Other than the participants knowing their own individual caloric expenditure during CWT and steady state aerobic exercise, there are no tangible benefits for the participant.

Procedures

Testing will consist of three separate sessions at the Eastern Washington University Recreation Fitness Center. The first day will begin with anthropometric measurements that will include height and weight. The 0 - 10 Borg RPE scale will then be described to each participant as well as the proper way in which it should be utilized during exercise. Familiarization with the CWT machines and protocol will take place next. Each participant will have time to become aquatinted with and fitted for each machine. Participants will then be instructed how to properly perform each lift and given an opportunity to perform each. Next, 1RM values will be obtained for each lift. After the completion of a general warm-up and a warm-up set on each machine of 8 repetitions at an estimated 50% of their 1RM max, each individual will attempt 2 repetitions at about 80% of their estimated 1RM. It will be ideal to obtain 1RM values within 2 – 3 attempts. At the completion of 1RM testing, the participant will complete a five-minute cool down on a T7xi Matrix Treadmill.

Prior to the second day of testing, the researcher will calculate each participant's 1RM value for each lift. To begin the second day of testing, each participant will then be fitted for the K4b© and a Polar Heart Rate Monitor. They will begin with a five-minute warm-up on a treadmill. The participant will then complete the CWT training protocol. It will be approximately twenty minutes in length with thirty seconds per station. The circuit will be completed three times with rest only allowed while moving from machine to machine. Each station will consist of 15 repetitions at a cadence of 60 beats per minute or lift 1 sec, down 1 sec. Heart rate and RPE values will be taken every two minutes throughout the twenty-minute protocol. Once the participant has reached the end of the protocol, they will complete an active five-minute cool down. No data will be collected during this part of the protocol. After completing the CWT, the average HR for the CWT session will be calculated for each participant by the heart rate monitor.

The third day of testing will occur between 2 & 5 days after the first bout of testing. Each participant will be once again fitted for the K4b©, and the mask will be adjusted as the investigator deems necessary. A Polar heart rate monitor will also be utilized again. The participant will begin by jogging at self-selected speed on a T7xi Matrix Treadmill .The speed will be increased .2 mph every 60 - 120 sec until the average HR is elicited that was

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recorded during CWT. The participant will complete twenty minutes of jogging at this intensity. Heart rate and RPE values will be once again obtained every two minutes. Following the completion of the steady state exercise, the participant will complete a five-minute active cool down. Your participation in this study will last approximately 1 hour on three separate testing days to complete all measurements and protocols.

Risk, Stress or Discomfort
The risks for you are minimal. A K4b© will be used to record changes in VO_2 values. It will not inhibit your ability to breath, is not dangerous, and is completely painless. You will also be asked to wear a heart rate monitor chest strap and watch during both protocols. Minor irritation or skin redness may occur from the chest strap. Lastly, the common discomforts associated with exercise are expected (i.e., acute fatigue). Please notify the principal investigator if you begin to feel any abnormal effects that you have not felt before during exercise.

Other Information
Your participation in this study is strictly voluntary, and you may decide to withdraw at any time without penalty. Only the principle investigator and supervising faculty advisor will have access to your data. If you decide to no longer be part of the study, all of your data will be immediately destroyed. If you have any questions or wish to learn more about this study, please contact Breann Booher at the phone number or email address listed at the beginning of this form.

__________________________ ____________
Signature of Principal Investigator Date

The study described above has been explained to me and I voluntarily consent to participate in this research. I have had the opportunity to ask questions. I understand that by signing this form I am not waiving my legal rights. I understand that I will receive a signed copy of this form.

__________________________ ____________
Signature of Subject Date

If you have any concerns about your rights as a participant in this research or any complaints you wish to make, you may contact Ruth Galm, Human Protections Administrator (509-359-6567), or rgalm@ewu.edu

Christi Brewer, Ph.D.
Physical Education, Health and Recreation Department
200 Physical Education Building • Cheney, WA 99004-2465
509.359.2485 • Fax 509.359.4833 • cbrewer7@ewu.edu

Appendix E

Modified Borg RPE

Perceived Exertion Scale
(Modified Borg Scale)

Perceived exertion is simply "how hard this activity feels to you." It refers to the total amount of effort you put forth It takes into account your feelings of exertion, physical stress and fatigue. Try not to focus on any one factor, such as leg discomfort or shortness of breath; rather, think about your **total, inner feeling** of exertion. Do not include incisional pain in the rating if you have had surgery.

- A rating of "0" means you feel no exertion or breathlessness.
- A rating of ".5" means you feel the same as if you were sitting comfortably in a chair.
- A rating of "10" means that you are putting forth the most effort you can possibly give.

Perceived Exertion Scale

0 =	No exertion/breathlessness
.5 =	Very, very light
1 =	Very light
2 =	Light
3 =	Moderate
4 =	Somewhat hard
5 =	Hard
6 =	
7 =	Very Hard
8 =	
9 =	Very, Very Hard
10 =	Maximal

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VITA

Author: Breann M. Booher, LAT, ATC

Place of Birth: Bremerton, Washington

Undergraduate School(s) Attended: Eastern Washington University

Degrees Awarded

Bachelor of Science in Athletic Training, 2013, Eastern Washington University

Honors and Awards

Graduate Assistantship, PEHR Department, 2013-2015, Eastern Washington University

Graduated Magna Cum Laude, 2013, Eastern Washington University

Athletic Training Student of the Quarter, Spring 2013, Eastern Washington University

Iota Tau Alpha Chapter President, 2012-2013, Eastern Washington University

Foundation Scholarship Recipient, 2012, National Athletic Trainers' Association

Richard Irvin Scholarship Recipient, 2012, Northwest Athletic Trainers' Association

Athletic Training Student of the Year, 2012, Big Sky Conference

National Residence Hall Honorary Chapter Member, 2010-2013, Eastern Washington University

Female Club Sport Athlete of the Year, 2010-2011 & 2012-2013, Eastern Washington University

National Player of the Week, 2011, National Club Softball Association

Professional Experience

Certified Athletic Trainer, Elite Physical & Sports Therapy & Mt. Spokane High School, Mead, Washington, May 2015 – June 2016

Interim Assistant Certified Athletic Trainer (Women's Basketball), Eastern Washington University Athletics Department, Cheney, Washington, Fall 2014