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Physiological Effects of a Kettlebell Workout versus a High-Resistance Circuit Workout

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Abstract

Purpose: To compare the physiological effects of a single kettlebell workout to a high-resistance circuit workout in resistance-trained males. Methods: 12 resistance trained healthy males (age: 24 ± 2.97 years; height: 1.75 ± 0.064 m; body mass: 75.99 ± 8.46 kg) participated in this study. Participants had a familiarization visit and two subsequent experimental visits (kettlebell workout; circuit workout). The kettlebell workout consisted of 12-minutes of standardized kettlebell swings. The circuit workout consisted of three sets of 6 repetitions of smith machine squats, bench press, leg curl, and lat pulldown. Heart rate, rectal temperature, skin temperature, blood lactate, rating of perceived exertion, muscle pain, and thermal sensation were measured throughout. Statistical analysis was done using one-way repeated measures ANOVA and a one-sampled T-test both with alpha set at 0.05. Results: More work was performed in the kettlebell swing workout compared to circuit workout ($p<0.006$). Heart rate was significantly higher throughout exercise for kettlebell ($p<0.001$) compared to circuit workout. Core temperature was significantly higher post-exercise in kettlebell compared to circuit workout (KB: Post-exercise = 38.03 ± 0.342 ˚C; CW: Post-exercise = 37.43 ± 0.341 ˚C*, respectively;* $p<0.008$). Rating of perceived exertion, and thermal sensation were significantly higher during kettlebell than circuit workout (both $p<0.05$). Muscle pain was significantly higher the last two measurements of exercise in kettlebell than the circuit workout ($p<0.006$). Conclusion: The findings show that the kettlebell swing workout tended to be perceptually harder, increasing feeling of heat stress, muscle pain, and had a higher sustained heart rate during exercise compared to the circuit workout.

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Chapter 1: Introduction

With the increasing rate of obesity in today's society, the need for exercise and proper diet is at an all-time high. As people enter the workforce, schedules get busy and exercise gets put on the backburner and because of this, there has been an increasing need for exercises that can be done in just a few minutes a day. Two types of exercise that can be an efficient use of time are kettlebells and circuit training. Circuit training has been increasing in popularity over the last few decades. It is an exercise program that was developed by R. E. Morgan and G. T. Adamson in 1953 at the University of Leeds in England (Adamsom, 1959). The variety of types of circuit workouts are aerobic circuits, high-resistance circuits, combinations of both aerobic and resistance training, and anything in between. The main idea in a circuit workout is having a reduced rest period between sets and exercises. In a typical resistance workout, a person might rest for a given period of time after performing a set of an exercise. In a circuit workout, the rest period would only be enough to move to another exercise and begin it immediately. This lack of rest has been shown to elicit some cardiovascular benefits because heart rate stays elevated consistently unlike traditional strength training where heart rate and blood pressure elevate during the exercise and then back down relatively close to resting levels between sets.

Kettlebell's origins come from being used by Russian strongmen called "grieveks." A kettlebell simply looks like a cannonball with a rounded handle on top of it, and they have increased in popularity in the United States in the last 20 years (Tsatsouline, 2006). Kettlebells can be used for a variety of exercises. The most popular exercises are: the kettlebell swing, goblet squat, clean and press, snatch, and the Turkish get-up. Kettlebell workouts tend to last anywhere from 10-40 minutes and are higher intensity in nature. There has been some evidence that this "new" workout that can elicit cardiovascular and strength benefits (Farrar, Mayhew, & Koch, 2010; Hulsey, Soto, Koch, & Mayhew, 2012; Jay, et al., 2011; Jay, et al., 2013; Lake & Lauder, 2012; Lake & Lauder, 2011; Otto III, Coburn, Brown, & Spiering, 2012). These workouts, being short in nature, offer a great way for people to exercise without dedicating hours during the week of being in the gym. However, little is known physiologically about this simple, yet comprehensive training tool. Only a handful of studies have been done examining the effects of kettlebell workouts (Budnar, Duplanty, Hill, McFarlin, & Vingren; Farrar, Mayhew, & Koch, 2010). Just like the circuit-training workouts, kettlebell workouts are shorter in nature than traditional strength workouts or even long runs. They could also be considered by some, efficient, in the sense that significant exercises effects occur in less time due to the intensity of the exercise.

With as many events that can go on during an average person's week, some feel that they do not have time to exercise or do not have 4-5 hours a week to dedicate to drive to the gym and exercise. Many people have tried many different workouts that are shorter in nature that have been shown to be effective to increase overall health. But as with most of the "newer" exercise routines, not much research has been done to show how effective that particular routine may be. There has been much research done with circuit training and its training effects, but not much with acute effects. On the other hand, the kettlebell is relatively new to the American exercise scene and there are few studies comparing acute kettlebell training bouts.

The purpose of this study is to examine the effects of core temperature, skin temperature, blood lactate, and perceptual scales that have not been measured together comparing these two types of workouts before. It is hypothesized that the kettlebell workout will result in a higher core temperature, higher blood lactate, and higher perceptual readings than a high-resistance circuit workout.

Chapter 2: Review of Literature

Circuit Workouts and Training

Cardiovascular Effects

Acute effects of circuit workouts. With high-resistance circuit training, studies have examined the acute effects of a circuit workout on the cardiovascular system (Gotshalk, Berger, & Kraemer, 2004; Wilmore, et al., 1978; Beckham & Earnest, 2000). Studies show that doing a single resistive circuit training workout with moderate to high resistance, participants were able to maintain at or above 55% of heart rate max (Gotshalk, Berger, & Kraemer, 2004; Wilmore, et al., 1978; Beckham & Earnest, 2000). Along with heart rate, these studies also examined the effects of resistive circuit training on relative VO_2. During these circuit workouts, VO_2 was maintained at or above 30% of VO_{2max}. Some studies showed that the circuit workout was at a high enough intensity on VO_2 that, according to guidelines from the American College of Sports Medicine, it could potentially have cardiovascular benefits. However others have calculated VO_2's too low to have potential benefits (Gotshalk, Berger, & Kraemer, 2004; Wilmore, et al., 1978; Beckham & Earnest, 2000).

Cardiovascular Effects of Circuit Workout Training. There have also been studies that have examined the possible training effects that resistive circuit training can have on cardiovascular fitness (Takeshima, Rogers, Islam, Yamauchi, Watanabe, & Okada, 2004; Romero-Arenas, et al., 2013; Gettman, Culter, & Strathman, 1980; Alcaraz, Perez-Gomez, Chavarrias, & Blazevich, 2011; Davis, et al., 2011). The premis behind circuit training is the idea that even though you are not doing classical aerobic exercise, your heart rate is elevated for a duration that could possibly enhance cardiovascular fitness while also improving muscular strength. There are many types of circuit training that can be done. These include aerobic circuit training, high-resistance circuit training, or a combination of both aerobic and resistance circuits. Aerobic circuit training usually consists of exercises not using resistance weights, such as, jumping jacks, running in place, running short distances, burpees, etc. Resistance circuits contain exercises using weights to help increase muscular srength and can include exercises from the most basic moves (i.e. bench press, shoulder press, leg press, etc.) to more complex movements (i.e. squats, power cleans, dead lift, etc.) Takeshima *et al*. examined the effects of a combined aerobic and resistance circuit training program in older adults. After participating in a 12-week training program, participants significantly increased their VO_2 at the lactate threshold and also their VO_{2peak} (Takeshima, Rogers, Islam, Yamauchi, Watanabe, & Okada, 2004).

Other studies have examined the effects of only high-resistance circuit training and cardiovascular fitness (Alcaraz, Perez-Gomez, Chavarrias, & Blazevich, 2011; Romero-Arenas, et al., 2013; Gettman, Culter, & Strathman, 1980). In these studies, participants performed resistive circuit training for 8, 12, or 20 weeks. All circuits included upper and lower body exercises and are considered anaerobic in nature. In all three studies, pariticipants went from one exercise with 0-30 sec in between each exercise. Results varied across studies in the effect on cardiovascular fitness. Alcaraz *et al*. saw a signifcant increase in trained males in shuttle run time to completion. This could be due to the increase in strength and explosive power from the high-resistance training. Gettman *et al*., observed significant increases in absolute VO_2 and no statistical significant improvement in relative VO_2. Romero-Arenas *et al*. observed a decrease in VO_2 in older adults after 12 weeks of training. Overall there is conflicting evidence whether or not a high-resistance circuit training program alone can significantly increase cardiovascular fitness.

Muscular Strength Effects

Training Effects of Circuit Workout Training. There have been few studies that have examined the effects of high-resistance circuit training and muscular strength. Alcaraz *et al.* and Romero-Arenas *et al.* compared high-resistance circuit training to traditional strength training in trained males for 8 weeks and older adults for 12 weeks respectively. After initial strength testing, and the exercise intervention, results show that high-resistance circuit training is just as effective in increasing muscular strength as traditional strength training is (Alcaraz, Perez-Gomez, Chavarrias, & Blazevich, 2011; Romero-Arenas, et al., 2013). In both studies, muscular strength was not signifcantly greater in the high-resistance circuit training group than the traditional strength training, but both studies showed a significant decrease in body fat percentage from training and compared to traditional strength training (Alcaraz, Perez-Gomez, Chavarrias, & Blazevich, 2011; Romero-Arenas, et al., 2013). These studies also show that in older adults there is a greater gain in lean body mass in older adults while circuit training compared to traditional strength training (Romero-Arenas, et al., 2013). There was no significant difference when comparing the two workouts for lean body mass gains in trained men (Alcaraz, Perez-Gomez, Chavarrias, & Blazevich, 2011). It is not surprising that there were significant increases in muscular strength with high-resistance circuit training. The same exercises were used for both the circuit workouts and traditional strength training and the only difference being in the amount of rest taken and time to complete the workout. The advantageous decision for one to perform a circuit workout compared to traditional strength training is that a circuit workout takes less time to complete. This may better accomadate persons who lack time in their daily routines for strength training

Kettlebell Workouts and Training

Cardiovascular Effects

Acute effects of kettlebell workouts. Only a handful of studies have examined the effects of an acute bout of kettlebell exercise on the cardiovascular system physiologically. Of these studies, researchers have observed surprising data showing that kettlebell training, could lead to improvement in cardiovascular performance (Farrar, Mayhew, & Koch, 2010; Hulsey, Soto, Koch, & Mayhew, 2012). Farrar *et al.* (2010) are possibly one of the first to measure cardiovascular effects of a kettlebell workout. During this acute study, they measured $\%VO_2$ max change of a single kettlebell swing workout.

Participants swung a kettlebell as many times as they could in 12-minutes while wearing a heart rate monitor and connected to a metabolic cart. Participants in that study averaged a relative VO_2 of 34.31 ± 5.67 $ml \cdot kg^{-1} \cdot min^{-1}$ for the 12-minute workout. At this relative VO_2, participants were able to keep their VO_2 at approximately 65% of their max. Based on the findings of this study, the exercise stimulus of the 12-minute swing workout would be sufficient enough to increase cardiovascular fitness (Farrar, Mayhew, & Koch, 2010).

Another study is Hulsey *et al.* (2012) who compared a single kettlebell swing interval workout to a matched perceived exertion treadmill workout. While the treadmill workout elicited greater stress on the cardiovascular system, the kettlebell workout, by the American College of Sports Medicine standards, provided a sufficient exercise stress to possibly elicit cardiovascular gains (Hulsey, Soto, Koch, & Mayhew, 2012).

Cardiovascular training effects of kettlebells. While some studies have observed the effects of one kettlebell workout, only one study could be found that observed the cardiovascular effects from long-term intervention. Jay *et al.*, observed the effects of kettlebell training over 8 weeks. 50 participants performed kettlebell training 3 days/week for 8 weeks. Each training session lasted for 20 minutes (Jay, et al., 2011). The results from training for 8 weeks for 20-minute sessions did not show any significant effects to increase aerobic capacity. Although Jay *et al.* did not observe any significant changes in cardiovascular capacity; they did not have participants perform the kettlebell swing workout that the acute studies have performed. They instead, had participants perform full body interval workouts that included the kettlebell two-handed swing, one-handed swing, and kettlebell deadlift (Jay, et al., 2011). The difference between the rest intervals and the lack of one, may have contributed to the lack of improvement of cardiovascular health. Other training studies should be done to fully observe if kettlebell training does significantly improve cardiovascular health.

Muscular Strength Effects

Acute Observations of Musculoskeletal Activation During Kettlebell Workouts. There have only been a few studies looked at for cardiovascular benefits of kettlebell workouts and training (Farrar, Hulsey, Jay). Some research has also focused on the muscle activation and muscle load of a single kettlebell workout, but these are also limited in number as well (McGill & Marshall, 2012; Zebis, et al., 2012; Lake & Lauder, 2011). Lake and Lauder (2012) studied the mechanical demands of performing the kettlebell swing exercise. Ground reaction forces were recorded for the swing, back squat, and jump squat exercises. From the ground reaction forces, they were able to measure peak and mean forces, net impulse, and peak and mean power. They observed that peak and mean force generally were greater for back and jump squats while peak and mean power was greater for the kettlebell swing exercise. These findings indicate that kettlebell training could lead to overall strength gains (Lake & Lauder, Kettlebell swing training improves maximal and explosive strength, 2012). McGill & Marshall also observed the effects of a kettlebell workout on the muscular system and found similar results. Besides looking at ground reaction forces, they observed muscular contraction of the low back extensors and gluteal muscles. They noted that during the kettlebell swing workout, the "hip-hinge" movement improves low back and gluteal strength. They observed low back extensor muscles contracting at approximately 50% of maximum voluntary contraction while gluteal muscles were about 80% of maximum voluntary contractions (McGill & Marshall, 2012).

Muscular Strength Improvements with Kettlebell Training. Many other studies have examined the effect of kettlebell training on muscular strength and power (Lake & Lauder, Kettlebell swing training improves maximal and explosive strength, 2012; Otto III, Coburn, Brown, & Spiering, 2012; Jay, et al., 2013; Manocchia, Spierer, Lufkin, Minichiello, & Castro, 2013). Lake and Lauder studied the effects of kettlebell training on maximal and explosive strength. Participants in this study performed six-weeks of either kettlebell training or jump squat power training. Kettlebell training saw an increase of 9.8% in maximum strength and 19.8% in explosive strength. The results from these training interventions did not significantly differ from each other, although it does show that kettlebell training does significantly improve maximum and explosive training (Lake & Lauder, Kettlebell swing training improves maximal and explosive strength, 2012). Other studies examined kettlebell training compared to traditional leg strengthening exercises. All studies done so far that have examined these training effects all observed similar results. They all observed significant gains in leg strength through kettlebell training, although none were greater than traditional leg strength training (Lake & Lauder, Kettlebell swing training improves maximal and explosive strength, 2012; Otto III, Coburn, Brown, & Spiering, 2012; Jay, et al., 2013; Manocchia, Spierer, Lufkin, Minichiello, & Castro, 2013).

Blood Lactate and Exercise

Many studies have examined the effects that exercise has on blood lactate levels. We know from previous research that as exercise progresses, lactate in the blood is cleared to match lactate production. As exercise continues or intensity increases there is a point where lactate production becomes greater than lactate clearance known as the lactate threshold (Brooks, Fahey, & Baldwin, 2005). Previous research has also shown that training can increase one's lactate threshold. This increase in lactate accumulation has been shown to be a valid predictor of fatigue and how quickly one fatigues while exercising (Brooks, Fahey, & Baldwin, 2005). One study observed the effects of training on lactate threshold, metabolic clearance rate, and rate of appearance. The researchers used 6 trained and 6 untrained individuals for an exercise bout of 60-minutes. Each workout was done at a previously determined intensity that corresponded with their lactate threshold. The results of their study showed that trained individuals have a higher lactate threshold, and a higher metabolic rate of clearance (Messonnier, Emhoff, Fattor, Horning, Carlson, & Brooks, 2013).

Lactate and Circuit Workout Training. Some studies have examined the effects of circuit weight training on lactate accumulation in the blood. These studies, when looking at circuit training, have shown a significant increase in blood lactate concentrations during exercise (Skidmore, Jones, Blegen, & Matthews, 2012; Abel, Mortara, & Pettitt, 2011; Cupeiro, et al., 2012). Skidmore *et al.* and Cupeiro *et al.* both used different types of circuit workouts to compare against and the effect that those circuits had on blood lactate concentrations. Cupeiro *et al.* compared a machine weight circuit vs. a free weight and combined free and machine weight circuits. They found that the machine weight circuit protocol elicited the highest blood lactate concentrations post-exercise (Cupeiro, et al., 2012). Skidmore *et al*. also compared different circuit protocols with one another. They compared a traditional resistance circuit workout, an aerobic circuit workout and a combination of both resistance and aerobic circuit workout. Blood lactate signficantly increased for all three protocols with the highest taking place in the combined resistance and aerobic circuit workout (Skidmore, Jones, Blegen, & Matthews, 2012). From these studies we know that lactate levels increase due to the small rest intervals of circuit training combined with the heavy resistance of resistance circuit training. If one is looking to increase their lactate threshold while increasing or maintaining strength, a combination of aerobic and resistance circuit training program may be beneficial.

Lactate and Kettlebell Exercise. Only one study could be found that has observed the acute findings of a kettlebell workout on blood lactate concentrations. Budnar *et al*. observed the hormone responses during a 12-minute kettlebell swing workout. They specifically observed growth hormone, cortical, testosterone, and lactate concentrations before, immediately after, 15 minutes post-exercise, and 30 minutes post-exercise. From their findings, they observed an increase in blood lactate following exercise, with the highest lactate concentrations being immediately after exercise (Budnar, Duplanty, Hill, McFarlin, & Vingren).

Skin and Core Temperature

As we exercise, our body temperatures increase due to the by-product of heat from muscular contractions (Brooks, Fahey, & Baldwin, 2005). Formenti *et al.,* observed trained and untrained females and their response to exercise. Their study shows that trained females responded more quickly to changes in muscle temperature than untrained females (Formenti, et al., 2013). Regulation of core temperature is tightly controlled by the human body and resting temperatures can range from 36.5°C-37.5°C. Core temperature is a result of heat gain/production versus heat loss to the environment. One of the major drivers of core temperature is exercise intensity because metabolic heat production is directly related to intensity of exercise (Brooks, Fahey, & Baldwin, 2005). Skin temperature is less than that of core temperature during exercise due to sweating, and heat transfer via conduction, evaporation, and radiation. Blood flow can also help with body temperature regulation through more superficial vessels, thus also changing skin temperature. Skin temperature therefore is altered by a variety of variables (Brooks, Fahey, & Baldwin, 2005).

Skin and Core Temperature and Circuit Workout Training. No studies could be found that studied the effects of a high-resistance circuit workout on skin or core temperature. This study is the also the first known study to examine the effects of a high-resistance circuit workout on skin and core temperature.

Skin and Core Temperature and Kettlebell Exercise. Currently there is no research that could be found that has looked at the effects of a kettlebell workout or training on skin and core temperature. This study will be the first known study to examine the effects of a kettlebell workout on skin and core temperature.

Chapter 3: Methods

There were 20 male participants used in this study. All participants were 18-39 years of age and had been resistance training for a minimum of 2 times per week for the previous 18 months. No participants had any pre-existing medical conditions. Participants made 3 visits to the Human Performance Laboratory. Each visit was separated by a minimum of 48 hours. The first visit was a familiarization visit to determine each participant's 6-repetition maximum (6RM) for the following exercises: smith machine squat, bench press, leg curl, and lat pull-down. The second half of the visit, each participant was taught the kettlebell swing exercise by a certified kettlebell instructor. After the instructor determined the participant could safely and effectively perform the kettlebell swing, the participant then performed half (6 minutes) of the kettlebell workout. The following two visits were the kettlebell and circuit workout. Participants were randomly assigned which workout they would perform first.

Familiarization Visit. Upon arrival, each participant read and signed a University-approved informed consent form, and filled out a Medical History Questionnaire and an International Physical Activity Questionnaire. Participants were told not to consume any caffeine, alcohol, supplements, or over the counter drugs 24-hours prior to each intervention trial. After this, different measurements were taken from the participant. These included age, height, arm length, and leg length. After these measurements were taken, participants were then taken down to the university's weight-room to determine their 6RM for the lifts of the circuit workout (CW). For each exercise, participant's self-selected weight they thought was approximately 70% of their 6RM. Participants lifted this weight 6 times for their warm-up. After the warm-up set, approximately 5-10 lbs. were added each set following until the participant could no longer perform 6 repetitions in a single set. Following each set, participants rested for 2 minutes before performing the next set (Scudese, Willardson, Simao, Senna, Freita de Salles, & Miranda, 2013).

After the 6RM was determined for each exercise, a certified kettlebell instructor then taught participants the kettlebell swing exercise. Each participant was taught on the popular "hip-hinge" method of the swing and practiced until they were comfortable with the exercise and the instructor determined it could be safely performed (Tsatsouline, 2006). After it was determined the participant could safely perform the kettlebell (KB) swing exercise, participants then performed half (6 minutes) of the kettlebell swing workout to become more familiar with the intervention workout. After this was completed, participants were given a food log to fill out 12 hours prior to their first trial. After the first experimental visit, participants were given back their food logs to try to replicate their meals as closely as possible before the completion of the second trial. Before each participant left, the three perceptual scales used during the experimental trials were explained to each participant. The first was the Borg's Rate of Perceived Exerction Scale (RPE). This scale was used to determine how much effort the participants felt they were exerting during the exercise (Borg, 1982). The next scale that was used was the Thermal Sensation Scale (TS). Participants used this scale to numerically summerize how hot or cold they felt at particular time points during exercise (Robertson, 1994). The last scale that was used was the muscular pain scale. Participants again numerically summarized their pain in their muscles, specifically in their thighs (Cook, O'Connor, Eubanks, Smith, & Lee, 1997).

Kettlebell Workout Trial. Upon arrival to the Human Performance Laboratory, participants filled out a 24-hour history form. After this, the participant was given a urine cup, scale, and prviate bathroom. They then provided a small urine sample, used the restroom and then nude body-weight was determined. Urine specific gravity was determined (<1.030) to make sure each participant was adequately hydrated (SPER Scientific, Scottsdale, AZ). After hydration status was determined, pre-exercise blood lactate levels were determined (Accutrend Lactate Analyzer, F. Hoffman-La Roche Ltd., Basel, Switzerland). After resting blood lactate was determined, the participant inserted a rectal thermometer 15cm past the anal sphinctor (Lee, Wakabayashi, Wijayanto, & Tochihara, 2010). After the rectal thermometer was in place, skin temperature probes were taped onto the participant in 4 locations (lateral deltoid, chest, mid-thigh, and calf) (TC-2000 Thermocouple meter, Sable Systems International, Las Vegas, NV) Mean skin temperature was calucated using the Ramanathan equation (Parsons, 2003):

Mean skin temperature = (0.30 * temperature of upper chest (˚C)) + (0.30 * temperature of lateral deltoid (˚C)) + (0.20 * temperature of anterior thigh (˚C)) + (0.20 * temperature of lateral calf (˚C))

After skin temperature probes were taped on, a heart rate monitor was straped onto the participant (Polar Electro, Kempele, Finland). Pre-exercise values for each measurement were taken and recorded (core temperature, skin temperature, and heart rate). After measurements were taken, subjects then performed a two-minute warm-up on a cycle ergometer (Monark AB, Varberg, Sweden) at ½ kg of resistance at 50 rpm (Farrar, Mayhew, & Koch, 2010; Thompson, Gordon, & Pescatello, 2010).

After the warm-up was complete, measurements were recorded again. Participants then proceded to perform the kettlebell swing workout. Participants swung a 35 lb (~16kg) kettlebell for 12-minutes. They were encouraged to swing the kettlebell as many times as possible in the 12-minute period but not as fast as they can. Heart rate, rectal core temperature, mean skin temperature, and number of swings were recorded after every minute of the workout. Every four minutes during the workout, perceptual scales were asked and recorded. After the 12-minute workout was completed, the participant then proceded to cool-down which was identical to the warm-up. Approximately 3-minutes after completetion of the workout, post-exercise blood lactate was taken. After blood lactate was taken and recorded, skin temperature probes and heart rate monitor were removed. The pariticpant then went to the restroom to remove the rectal thermometer, wipe any remaining sweat off, and then nude body weight was taken again. After the second body weight was taken and recorded, participants were allowed to leave.

Circuit Workout Trial. All procedures along with the pre-exercise and warm-up were the same as the kettlebell trials (with the exeption of the exercise performed). After the warm-up, participants were taken down to the university weight room. Resistance for each exercise was determined prior to the arrival of the subject and set at ~90% of their 6RM to make sure that all 6 repetitions of each set could be completed (Alcaraz, Perez-Gomez, Chavarrias, & Blazevich, 2011). While the participant performed the warm-up, one of the researchers went ahead and set the resistance on the machines so when the participant arrived to the weight room exercise was ready to begin. Participants then began the circuit workout. Participants started with the smith machine squat, followed by bench press, leg curl, and lat pulldown. Two subjects performed the glute machine instead of the leg curl due maintenance problems with the leg curl machine. Data was taken and recorded after each exercise while moving from one exercise to the next. No rest was taken between each exercise, and subjects moved from one exercise to the next at their own pace but were encouraged not to rest between sets. Upon completion of each round (1 set of each exercise) perceptual scales were asked and recorded. Upon completion of the circuit workout (~10 min), participants then proceeded back to the laboratory and blood lactate was taken immediately. After blood lactate was taken and recorded, participants then proceded to the cool-down and post exercise procedures identical to the kettlebell workout.

After all data was collected, work and power was estimated and calculated for each subject. Work was estimated since without video analysis, the exact distance traveled for the kettlebell swing workout could not be measured. Work was estimated based on arm-length of the participant and the range in which the kettlebell traveled (W=[(0.25*π*arm length(m))*number of swings]*(16kg*9.81m/s)). Based on the estimated work that was calculated, power was then calculated by taking each value of work and dividing by the time (in seconds) it took to complete the workout. This calculation is an estimate as well since work was estimated.

Statistics. Statistics were done using SPSS software v.20 (IBM Corporation, Armonk, NY). All data were analyzed using repeated measures ANOVA except for work. During each trial, RPE, MP, and TS were analyzed after each third of the workout (pre-exercise, time point 1 = 4 minutes into kettlebell exercise, and after the entire first set during the circuit workout, time point 2 = 8 minutes into kettlebell exercise, and after the entire second set during the circuit workout, time point 3 = 12 minutes into kettlebell exercise, and after the entire third set during the circuit workout), and post exercise. When comparing heart rate, rectal core temperature, and mean skin temperature, the measurement closest to every 60 seconds were used for each workout up until 9 minutes (540 seconds) to compare the closest points for each workout. This corresponded to minutes 1 and 2, 2 and 3, 3 and 4, 4 and 5, 5 and 6, 6 and 8, 7 and 9, 8 and 10, and 9 and 12, for kettlebell and circuit workout, respectively.

Chapter 4: Results

The kettlebell workout was 12 minutes (720 seconds) in length and participants averaged 301 ± 92 swings. The circuit workout varied per participant and averaged 9:12 (552 ± 133 seconds) in length.

Work & Power. It was estimated that the kettlebell swing workout averaged significantly more work than the circuit workout (KB= 83.16 ± 24.42 KJ, CW= 59.41 ± 9.38 KJ) (p=0.006). Power was calculated based on the amount of work done and the time it took to perform that work. There was no significant difference in power between the two workouts (KB= 115.50 ± 33.92 W, CW= 112.99 ± 31.61 W) (p=0.822).

Heart Rate. There was no difference in heart rate between workouts before exercise (p=0.235). Heart rate during the kettlebell workout was significantly higher (p=0.001) than the circuit workout (Figure 1) for each time point throughout both workouts. For both workouts, heart rate was significantly higher at the end of the workout compared to the beginning of the workout (p=0.001).

Body Temperature. There was no significant difference in core temperature before or during exercise between the two workouts (Pre: p=0.578, Time 1: p=0.824, Time 2: p=0.085, Time 3: p=0.157). It did increase significantly during exercise for both workouts (p=0.001). Core temperature after exercise was significantly higher in kettlebell exercise than in the circuit workout (p=0.008) (Figure 2). There was no significant difference at any time points in mean skin temperature between trials. Skin temperature did decrease significantly in both trials across time (p=0.001). This is probably due to an onset and increase in sweating during exercise (Figure 3). Sweat rate was calculated for both kettlebell and circuit workout (Mean: 0.33 ± 0.16 L/hr, 0.28 ± 0.08 L/hr respectively).

Blood Lactate. There was no difference of blood lactate levels between the trials (KB: pre= 2.06 ± 0.31 mmol/L post= 6.83 ± 3.31mmol/L; CW: pre= 2.10 ± 0.39 mmol/L, post= 7.15 ± 3.05 mmol/L). There were significant differences between pre- and post- measurements in each trial (p=0.001) (Figure 4).

Perceptual Measures. Rating of perceived exertion was significantly higher at every time point in the kettlebell trial compared to the circuit trial (p=0.001) (Figure 5). Muscle Pain was significantly higher in the last two measurements in the kettlebell trial compared with the circuit trial (Time 2: p=0.021, Time 3: p=0.002) (Figure 6). Thermal sensation was significantly higher at every time point in the kettlebell workout compared to the circuit workout (p=0.005) (Figure 7). The area under the curve was calculated for each participant for all measurements except blood lactate.

Chapter 5: Discussion

Kettlebell and high-resistance circuit workouts are shorter in duration than traditional strength training or cardiovascular training. This study examined the physiological effects of a single kettlebell workout and a single high-resistance circuit workout. The effects on core temperature, skin temperature, heart rate, blood lactate, rate of perceived exertion, muscle pain, thermal sensation were observed. The main finding from this study was the kettlebell swing workout elicited higher levels of heart rate and was perceptually harder than the high-resistance circuit workout while performing more total work. Core temperature was also higher in the kettlebell than the circuit workout after the completion of exercise.

Core temperature rose during both workouts and was significantly higher at the end of exercise than at the beginning for both (Figure 2). Although there was no significant difference between the two exercises before or during exercise, core temperature was significantly higher after exercise in the kettlebell trial than the circuit workout trial. There was a significant rise in core temperature at the end of the kettlebell workout in short amount of time. This rise could be influenced by the amount of muscle activation and work performed, and thus metabolic heat production. During the workout, participants were instructed to perform the "hip-hinge" form to perform the swing exercise (Tsatsouline, Enter the Kettlebell!, 2006). This motion is encouraged to activate the hamstrings and gluteus groups in a repetitive manner while also swinging the arms. Since heat is a by-product of muscular contraction, the participant's core temperature reading could be higher with kettle bell because of greater muscle activation from the greater amount of work being performed.

Skin temperature was measured during each trial and no significant difference was observed between the two trials. There was a significant difference over time for each trial. Each workout was performed in a controlled laboratory or fitness facility environment, so the small change in skin temperature is not surprising. The decrease in mean skin temperature could also be caused by sweating to cool the body. As participants exercised, their sweat rate increased thus causing the body to cool itself resulting in a lower mean skin temperature.

Blood lactate did not see significant changes between the trials during the workouts. Although there was a signifcant increase over time in each trial, the lack of significant difference between trials is most likely due to the reason that each workout is performing exercises with muscular contractions with resistance. Lactate is a by-product of muscular contraction and increases over time during exercise at it approaches the lactate threshold (Brooks, Fahey, & Baldwin, 2005). These are similar findings to other studies that have looked at lactate and increases in concentration with exercise (Abel, Mortara, & Pettitt, 2011; Brooks, Fahey, & Baldwin, 2005; Budnar, Duplanty, Hill, McFarlin, & Vingren; Cupeiro, et al., 2012; Messonnier, Emhoff, Fattor, Horning, Carlson, & Brooks, 2013; Skidmore, Jones, Blegen, & Matthews, 2012). This study reinforces that lactate concentration levels increase with exercise, even workouts short in nature.

Heart rate increased with both workouts over time, and was significantly higher in the kettlebell workout across the entire workout. This significantly higher heart rate is expected since more overall work was performed in the kettlebell workout compared to the circuit workout. Other studies have shown that the kettlebell swing exercise has a sustained heart rate at a very high rate across the entire exercise (Farrar, Mayhew, & Koch, 2010; Hulsey, Soto, Koch, & Mayhew, 2012). From previous research we know that a heart rate sustained above a certain level can help elicit cardiovascular benefits over time with training. Heart rate was sustained at a high enough level in this workout that it could have a training effect to increase cardiovascular capacity, although future research would need to be done (Thompson, Gordon, & Pescatello, 2010). Although the kettlebell heart rate was significantly higher, heart rate during the circuit workout was significantly higher during exercise than before exercise. This shows that high-resistance circuit training, just like kettlebell training, could possibly increase cardiovascular capacity based on heart rate. Future research should be done with this as well.

Participants were asked how they felt on three different scales used for perceptual measures. The first was the standard Rate of Perceived Exertion (RPE) scale. RPE was signifcantly higher across the three different time points in the kettlebell trial. Kettlebell being a newer exercise to the american fitness field seemed to be much harder for people (Hulsey, Soto, Koch, & Mayhew, 2012). This could be due to the fact that not everyone is comfortable and accustomed to using the kettlebell. This higher rate of perceived exertion is most likely influenced by the fact that compared to the circuit workout, more overall work was performed. The participants for this study have also been resistance trained and at least bi-weekly had been using traditional strength training exercises which the circuit workout was made up of. This familiarity and lack of familiarity with traditional strength training exercises and the kettlebell swing, respectively, could be a contributing factor of the higher recorded RPE across the workouts. Participants were also asked their muscular pain in their thighs during both workouts as well. Muscular pain was significantly higher in the last two time points in the kettlebell workout compared to the circuit workout. One reason for this significant difference is the repetitive motion the kettlebell swing workout has. Participants in the circuit workout were able to take breaks by going between lower- and upper-body exercises, which could have been long enough for the muscles of the thigh to recover. The kettlebell workout consistently used the leg muscles, especially those of the hamstrings and gluteal groups, and could therefore be the reason muscle pain was significantly higher. This repetitive motion along with the amount of work being performed on those muscle groups is most likely the cause of the signifciant amount muscle pain perceived. No previous studies have examined muscle pain during a kettlebell or circuit workout that could be found.

The last perceptual scale that was used was the thermal sensation scale. Thermal sensation was significantly higher during the kettlebell workout across all three time points. Although the participants exercised in a controlled environment the entire time, they felt hotter in the kettlebell workout. This increase in thermal perception could be a result of the increase in core temperature during exercise. Although core temperature in the kettlebell workout was not signifcantly higher during exercise, it was significantly higher post-exercise and this steady rise in core temperature from the onset to post-exercise may be the cause for a higher thermal sensation. This could be due to the fact that there was a steady rise in core temperature that ultimately lead to a significant difference post-exercise. This rise in core temperature is related to the amount of work being done, with heat being a metabolic by-product and the more work that is performed, the more heat is prodcued. Although there was a significant difference between both trials, there was also significant increase in each trial across time.

Work for each participant was estimated for both workouts for each participant. It was found that participants performed a significantly more amount of work during the kettlebell workout compared to the circuit workout. This could be due to the fact that participants are performing an average of 301 ± 92 swings compared to the circuit workout where a total of 18 repetitions were performed for each exercise. The work was attempted to be matched, but the kettlebell workout did however have a significantly higher total amount of work performed. This helps us understand why the perceptual scales for the kettlebell trial was significantly higher than the circuit trial. Not all of the participants were cardiovascularly trained and having a higher sustained heart rate is most likely not something that they are used too. This study may reinforce the idea of using the kettlebell as a supplemental cardiovascular training tool since a high amount of work can be performed in a relatively short period of time. Heart rate stayed at a consistently higher rate during the kettlebell exercise compared to the circuit workout. This may reinforce earlier findings that the kettlebell swing workout may increase cardiovascular fitness while increasing leg strength and explosive strength (Farrar, Mayhew, & Koch, 2010; Hulsey, Soto, Koch, & Mayhew, 2012; Lake & Lauder, Kettlebell swing training improves maximal and explosive strength, 2012) Having a higher sustained heart rate could also be impacting their perception on the difficulty along with the higher work load.

Chapter 6: Conclusion

This study has observed that a kettlbell swing workout may be more beneficial to perform for someone who is attempting to increase their overall health. It was observed that heart rate was sustained at a high level that could over time, increase cardiovascular capacity. It was also observed that the kettebell workout seemed harder to complete to participants. This might be a good workout for someone to use to mix up their routine who desires new exericses and enjoys higher intensities workouts. This also might benefit people to learn the exercise correctly and improve their fitness with this workout, although more future studies should be done to examine training effects. Participants in this study were able to perform a high amount of work, in a short amount of time which with consistent training could improve overall health in someone with very limited time.

Figures

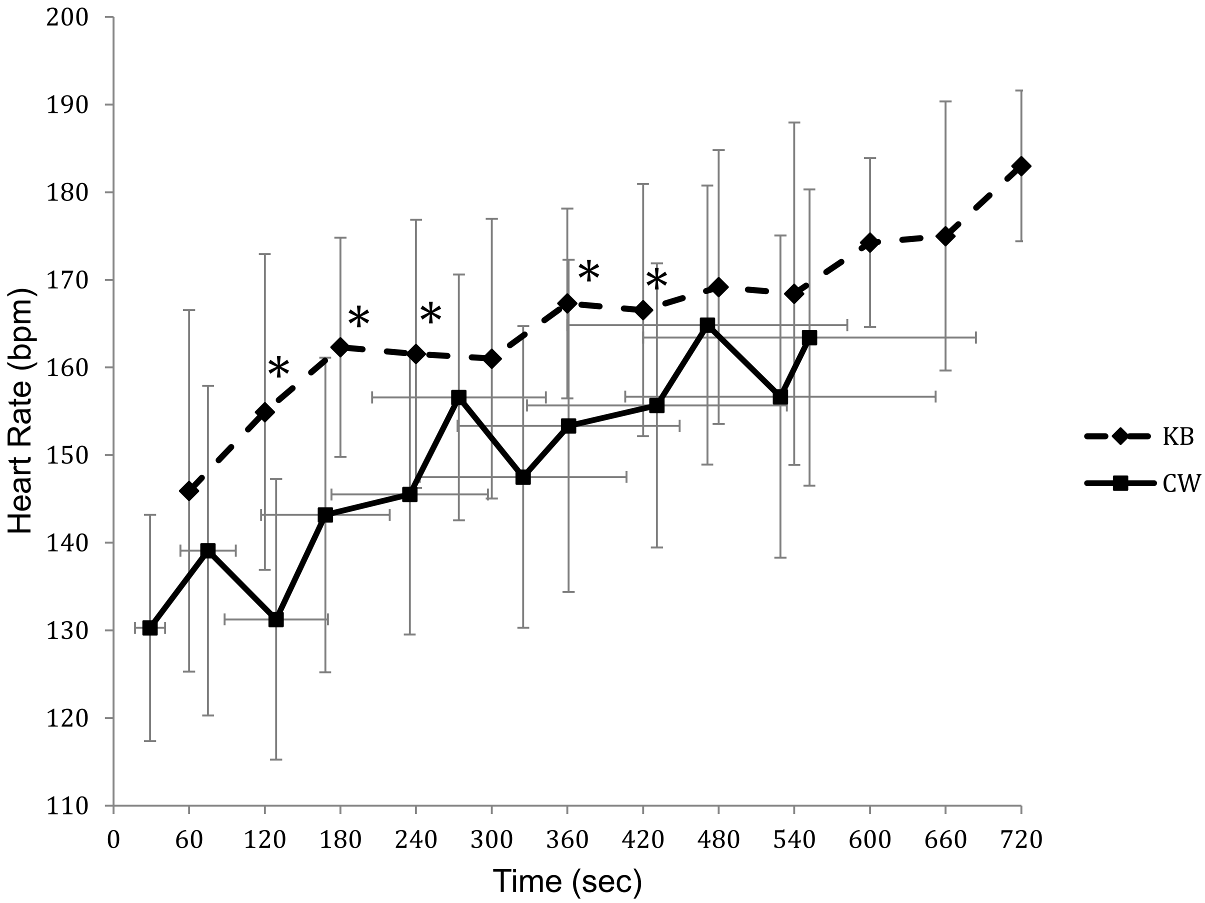

Figure 1 A. Heart rate during exercise for each workout. *denotes time points where KB is significantly higher than CW (P<0.05).

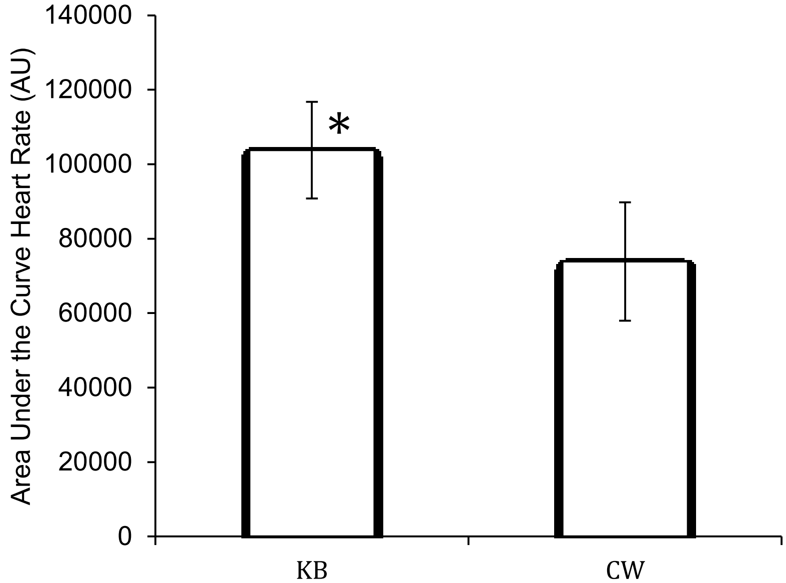

Figure 1 B. Heart rate area under the curve. *denotes time points where KB is significantly higher than CW (P<0.05).

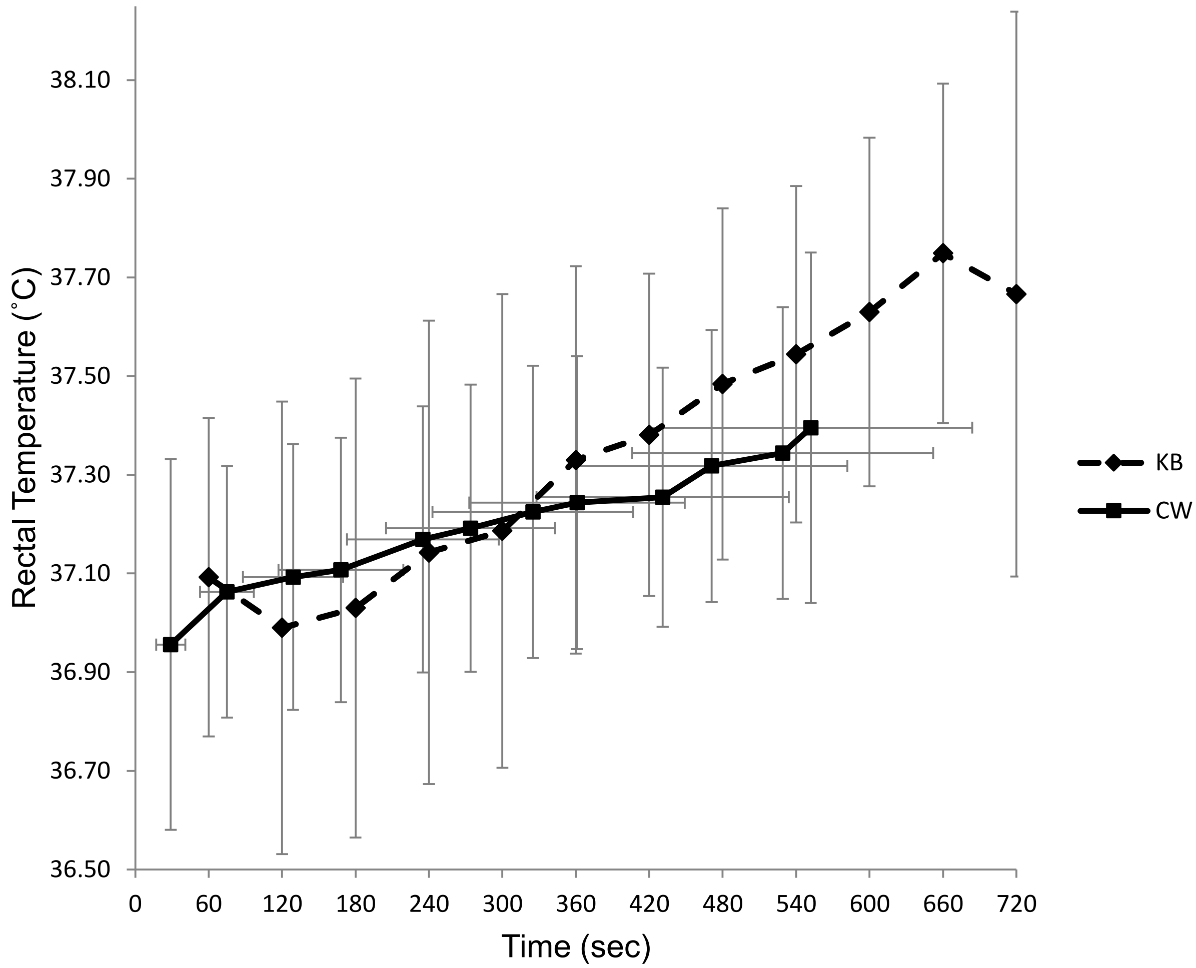

Figure 2 A. Rectal core temperature during exercise for each workout.

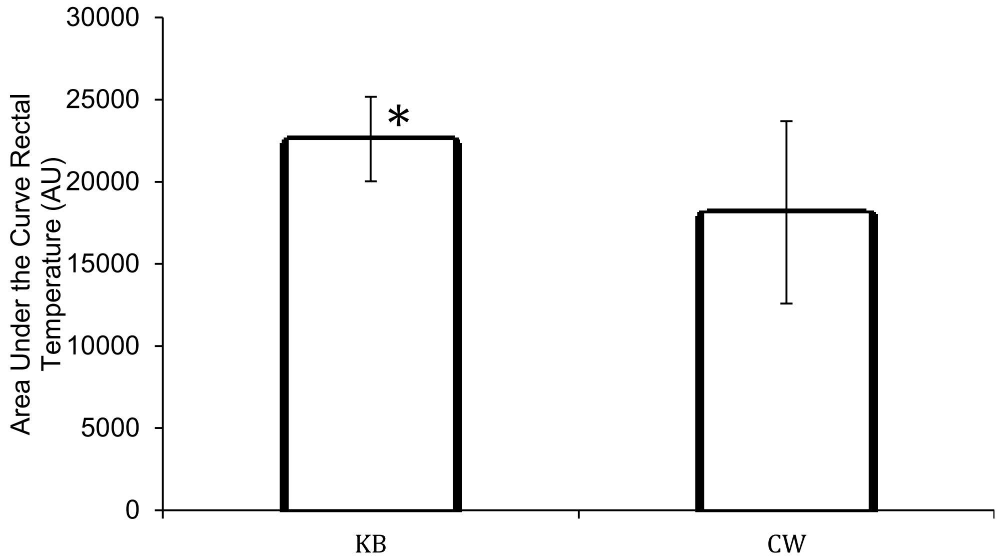

Figure 2 B. Rectal core temperature area under the curve. *denotes time points where KB is significantly higher than CW (P<0.05).

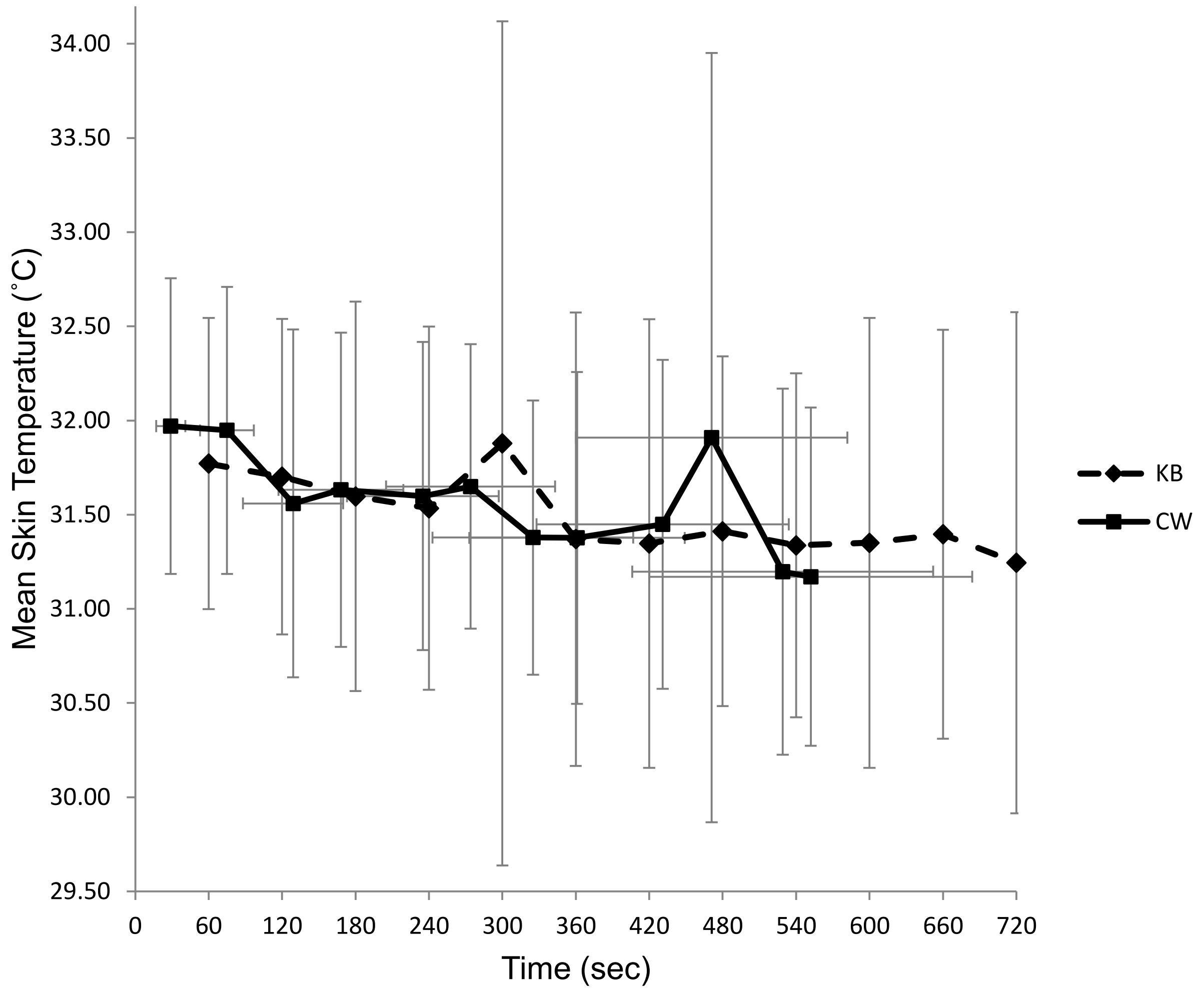

Figure 3 A. Mean skin temperature during exercise for each workout.

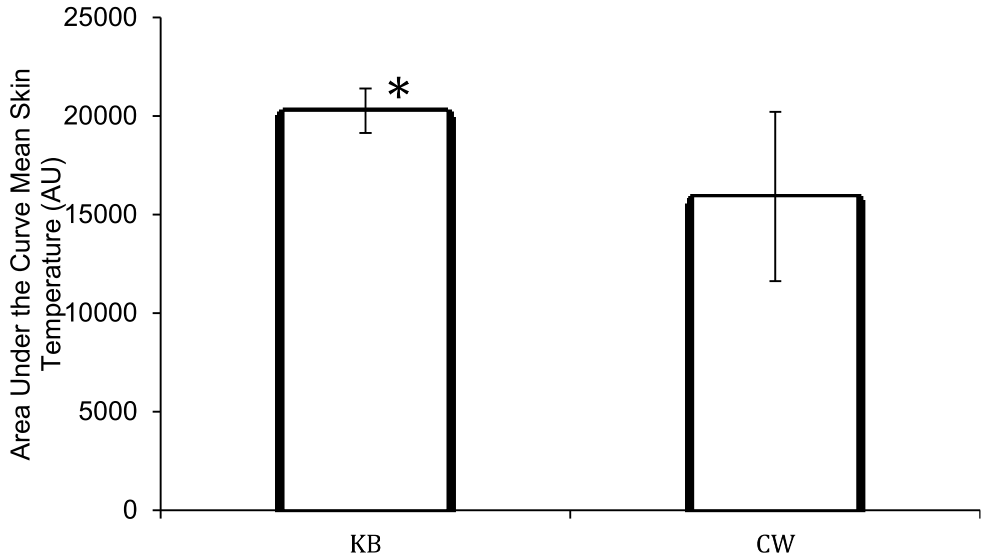

Figure 3 B. Mean skin temperature area under the curve. *denotes time points where KB is significantly higher than CW (P<0.05).

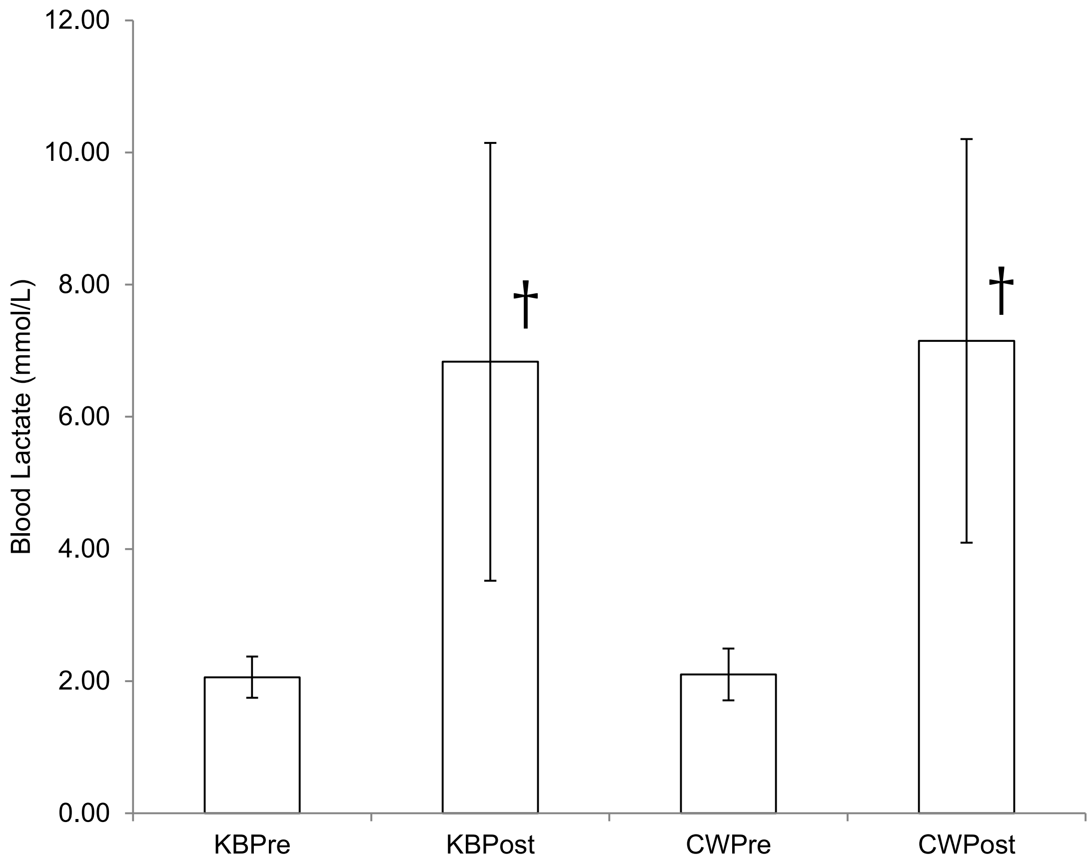

Figure 4. Blood lactate concentrations during exercise for each workout. Shows the three time points that all measurements were taken. Each time point is 1/3 of the exercise routine (Time 1= 4 minutes into workout for KB, or after completion of entire first set in CW) †denotes significant increases in lactate concentrations post-exercise compared to pre-exercise (KBpre= Kettlebell trial pre-exercise, KBpost= Kettlebell trial post-exercise, CWpre= Circuit Workout trial pre-exercise, CWpost= Circuit Workout post-exercise) ($P<0.05$).

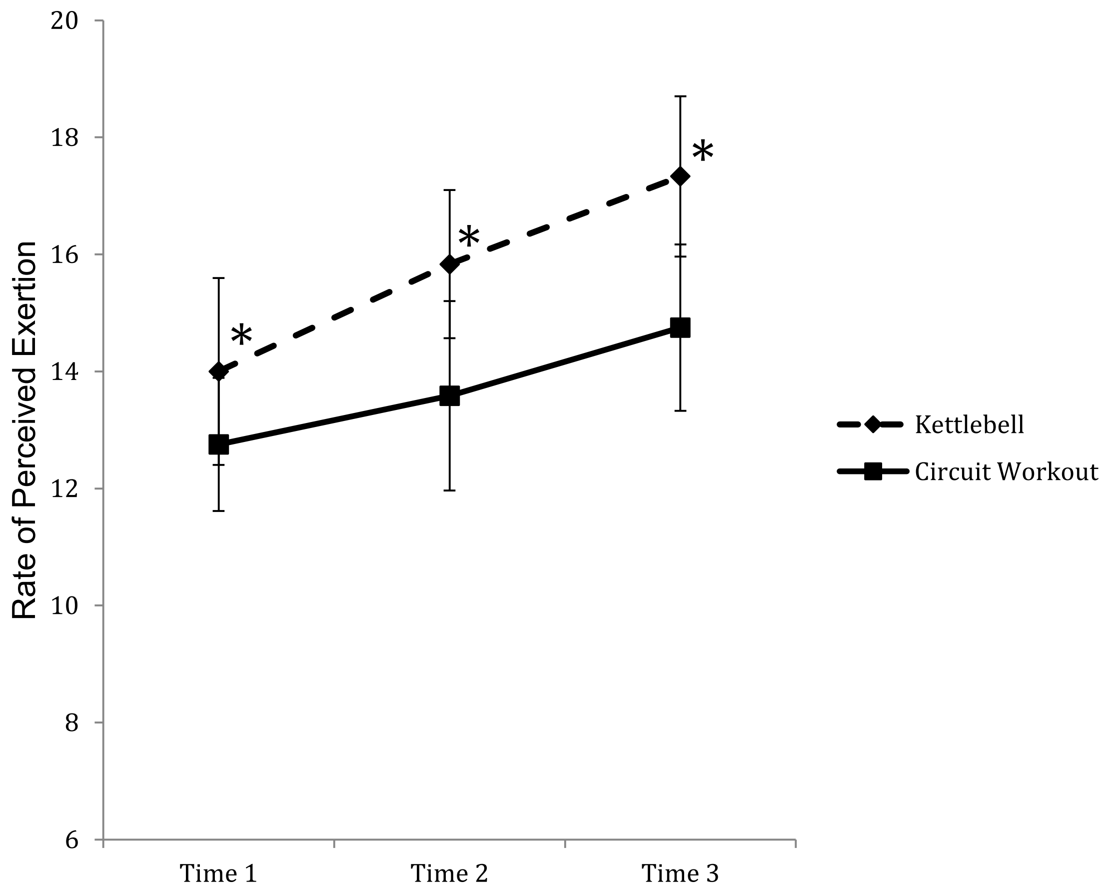

Figure 5 A. Ratings of Perceived Exertion during exercise for each workout. Shows the three time points that all measurements were taken. Each time point is 1/3 of the exercise routine (Time 1= 4 minutes into workout for KB, or after completion of entire first set in CW) *denotes time points where KB is significantly higher than CW ($P<0.05$).

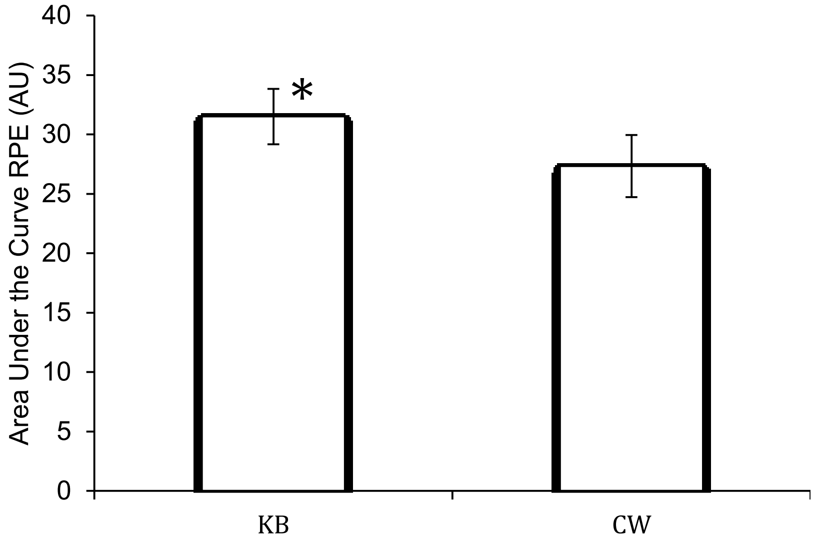

Figure 5 B. Rate of Perceived Exertion area under the curve. *denotes time points where KB is significantly higher than CW (P<0.05).

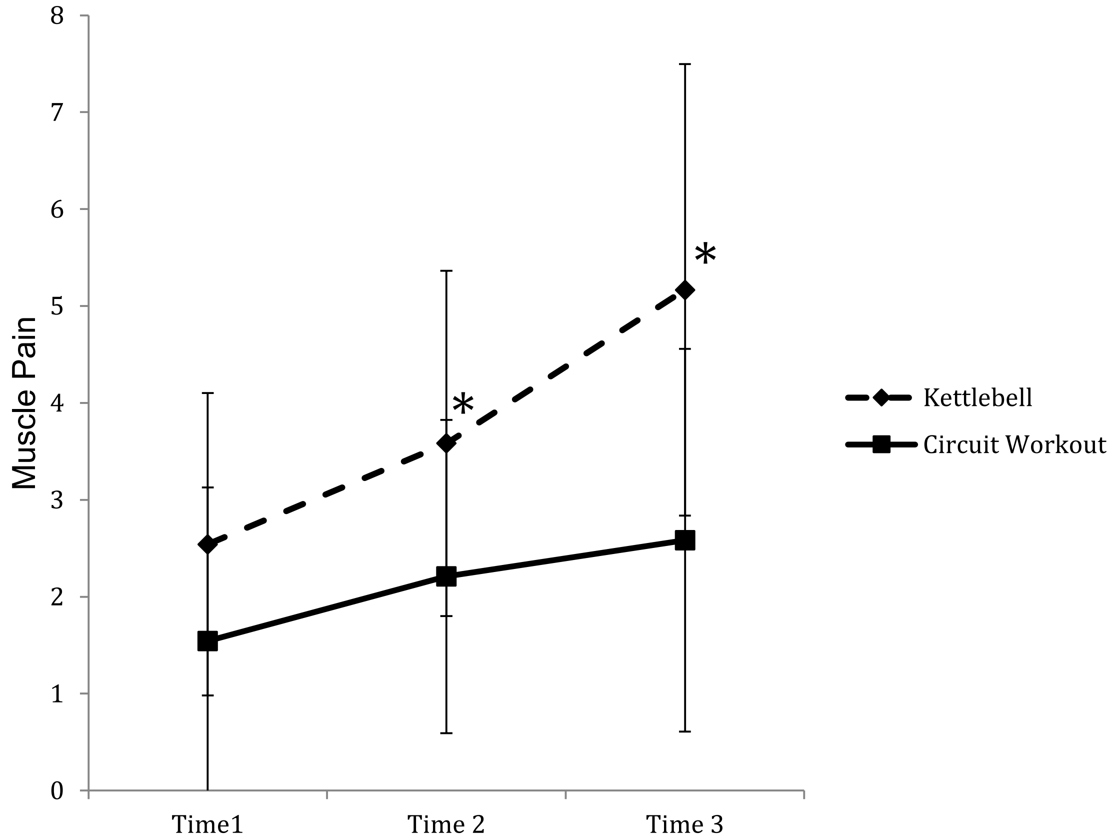

Figure 6 A. Muscle Pain in the thigh muscles during exercise for each workout. Shows the three time points that all measurements were taken. Each time point is 1/3 of the exercise routine (Time 1= 4 minutes into workout for KB, or after completion of entire first set in CW) *denotes time points where KB is significantly higher than CW (P<0.05).

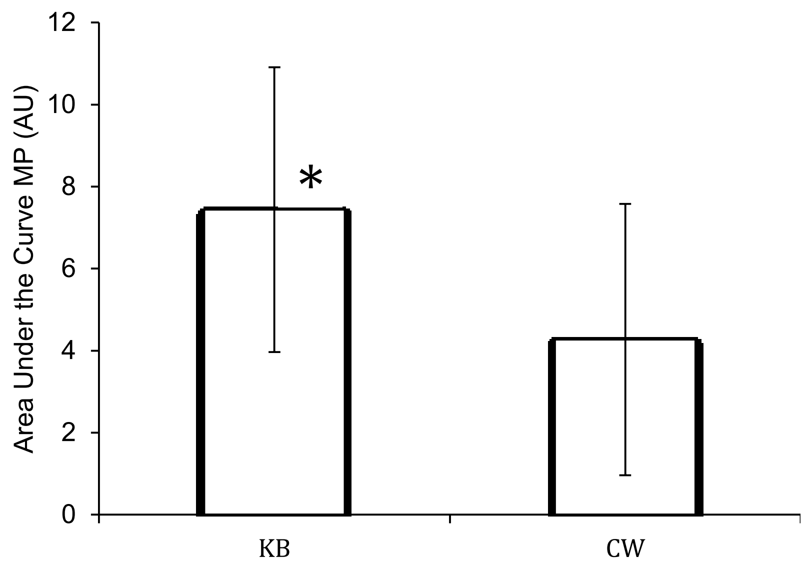

Figure 6 B. Muscle Pain area under the curve. *denotes time points where KB is significantly higher than CW (P<0.05).

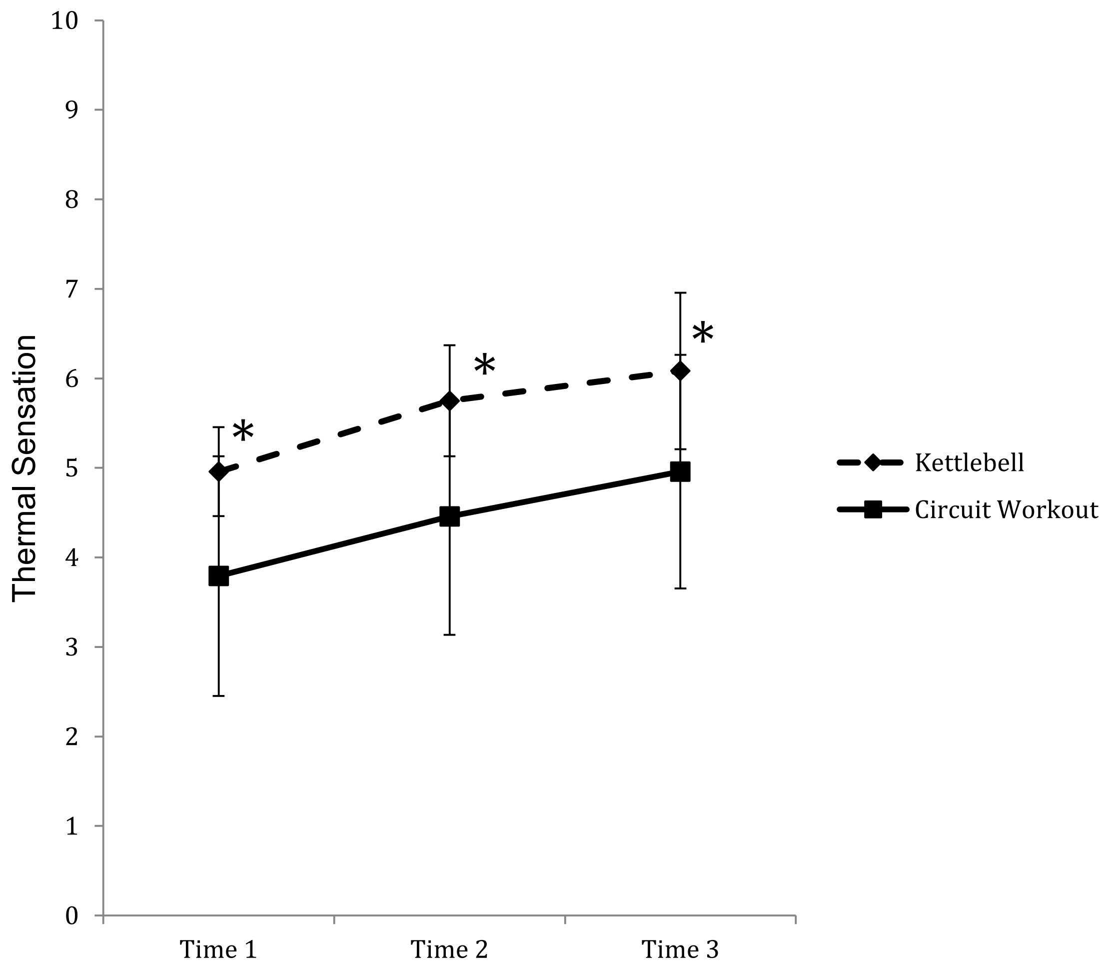

Figure 7 A. Thermal Sensation Rating during exercise for each workout. Shows the three time points that all measurements were taken. Each time point is 1/3 of the exercise routine (Time 1= 4 minutes into workout for KB, or after completion of entire first set in CW) *denotes time points where KB is significantly higher than CW ($P<0.05$).

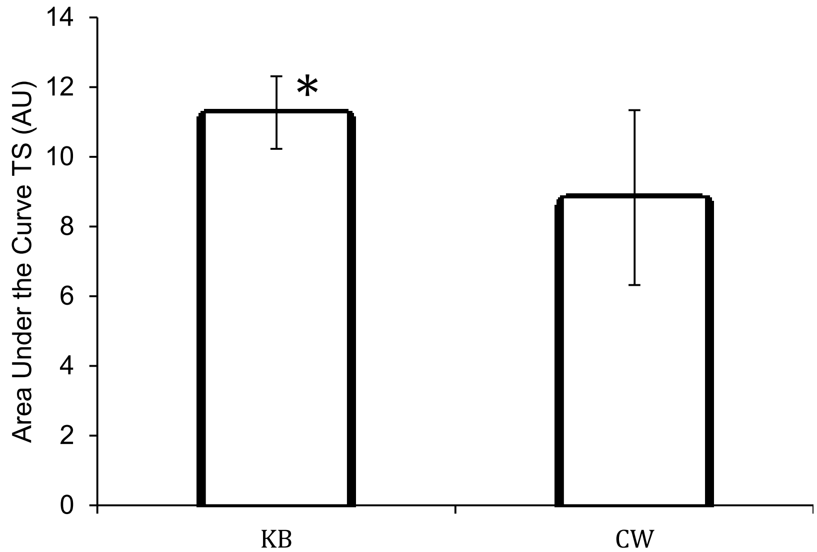

Figure 7 B. Thermal Sensation area under the curve. *denotes time points where KB is significantly higher than CW ($P<0.05$).

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Appendix A:

October 25, 2013

MEMORANDUM

TO:	Brett Schreiber Nicole Moyen Lauryn Blanton Melina Gonzalez Dani Teese Tyrone Washington Matthew Ganio	Matt Tucker Jenna Burchfield Hannah Anderson Ashley Six Forrest Robinson Stavros Kavouras
FROM:	Ro Windwalker IRB Coordinator	
RE:	New Protocol Approval	
IRB Protocol #:	13-10-140	
Protocol Title:	*Kettlebell versus Circuit Workout*	
Review Type:	☐ EXEMPT ☐ EXPEDITED ☒ FULL IRB	
Approved Project Period:	Start Date:	10/25/2013 Expiration Date: 10/14/2014

Your protocol has been approved by the IRB. Protocols are approved for a maximum period of one year. If you wish to continue the project past the approved project period (see above), you must submit a request, using the form *Continuing Review for IRB Approved Projects*, prior to the expiration date. This form is available from the IRB Coordinator or on the Research Compliance website (http://vpred.uark.edu/210.php). As a courtesy, you will be sent a reminder two months in advance of that date. However, failure to receive a reminder does not negate your obligation to make the request in sufficient time for review and approval. Federal regulations prohibit retroactive approval of continuation. Failure to receive approval to continue the project prior to the expiration date will result in Termination of the protocol approval. The IRB Coordinator can give you guidance on submission times.

This protocol has been approved for 20 participants. If you wish to make *any* modifications in the approved protocol, including enrolling more than this number, you must seek approval *prior to* implementing those changes. All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

If you have questions or need any assistance from the IRB, please contact me at 210 Administration Building, 5-2208, or irb@uark.edu.

Appendix B:

The Human Performance Laboratory, University of Arkansas is seeking

Males to Participate in an Exercise Study

<u>Please inquire if:</u>

- **you are 18-39 years old**
- **have no medical illnesses**
- **have performed ≥ 2 resistance training workouts per week over the last 18 months**

This study will involve 3 visits, 2 visits involve resistance exercise
(total time commitment ~ 5 hours)

<u>Contact:</u>
Brett Schreiber at (816) 868-4141
bschreib@uark.edu

The principal investigator is Matthew Ganio, Ph.D. This study has been approved by the University of Arkansas, Institutional Review Board for Human Studies, Fayetteville, AR.

Appendix C:

Flyer for electronic communication

Participants wanted for a research study to evaluate the effects of kettlebell and high-resistance circuit-training workouts on body temperature and blood lactate levels.

Seeking: 20 males; should be 18-39 years old; no chronic illness or injury; should have performed resistance exercise at least 2 days/week for the last 18 months.

This study will involve: 3 visits to the Human Performance Laboratory (approximately 1.5 hours per visit); moderate/vigorous exercise (kettlebell and high-resistance circuit-training on two separate occasions); heart rate monitoring; and a finger stick for a small blood sample

For details: telephone Brett Schreiber at (816) 868-4141 or bschreib@uark.edu

The principal investigator is Matthew Ganio, Ph.D. This study has been approved by the University of Arkansas, Institutional Review Board for Human Studies, Fayetteville, AR.

Appendix D:

HUMAN PERFORMANCE LABORATORY MEDICAL HISTORY QUESTIONNAIRE

PLEASE ANSWER ALL OF THE FOLLOWING QUESTIONS AND PROVIDE DETAILS FOR ALL "YES" ANSWERS IN THE SPACES AT THE BOTTOM OF THE FORM.

YES	NO		
yes	no	1.	Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
yes	no	2.	Has your doctor ever denied or restricted your participation in sports or exercise for any reason?
yes	no	3.	Do you ever feel discomfort, pressure, or pain in your chest w hen you do physical activity?
yes	no	4.	In the past month, have you had chest pain w hen you w ere not doing physical activity?
yes	no	5.	Do you lose your balance because of dizziness or do you ever lose consciousness?
yes	no	6.	Does your heart race or skip beats during exercise?
yes	no	7.	Has a doctor ever ordered a test for you heart? (i.e. EKG, echocardiogram)
yes	no	8.	Has anyone in your family died for no apparent reason or died from heart problems or sudden death before the age of 50?
yes	no	9.	Have you ever had to spend the night in a hospital?
yes	no	10.	Have you ever had surgery?

11. Please check the box next to any of the follow ing illnesses w ith w hich you have ever been diagnosed or for w hich you have been treated.

☐ High blood pressure	☐ Elevated cholesterol	☐ Diabetes
☐ Asthma	☐ Epilepsy (seizures)	☐ Kidney problems
☐ Bladder Problems	☐ Anemia	☐ Heart problems
☐ Coronary artery disease	☐ Lung problems	☐ Chronic headaches

YES	NO		
yes	no	12.	Have you ever gotten sick because of exercising in the heat? (i.e. cramps, heat exhaustion, heat stroke)
yes	no	13.	Have you had any other significant illnesses not listed above?
yes	no	14.	Do you currently have any illness?
yes	no	15.	Do you know of any other reason w hy you should not do physical activity?
yes	no	16.	Have you ever been diagnosed w ith diverticulitis, abdominal adhesions or have a history of abdominal obstructions or abdominal surgeries

17. Please list all medications you are currently taking. Make sure to include over-the-counter medications and birth control pills.

Drugs/Supplements/Vitamins	Dose	Frequency (i.e. daily, 2x/day, etc.)

DETAILS: ____

____

____

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____

____

____

Appendix D cont:

18. Please list all allergies you have.

Substance	Reaction

YES	NO	19. Have you smoked?	If yes, #/day	Age Started	If you've quit, what age?
yes	no	Cigarettes			
yes	no	Cigars			
yes	no	Pipes			

YES	NO	20. Do you drink alcoholic beverages?	If yes, how much?	How often?
yes	no			

21. Do you have a family history of any of the following problems? If yes, note who in the space provided.

☐	High blood pressure		☐	Heart disease	
☐	High cholesterol		☐	Kidney disease	
☐	Diabetes		☐	Thyroid disease	

22. Please check the box next to any of the following body parts you have injured in the past and provide details.

☐	Head		☐	Hip		☐	Calf/shin	
☐	Neck		☐	Thigh		☐	Shoulder	
☐	Upper back		☐	Knee		☐	Upper arm	
☐	Lower back		☐	Ankle		☐	Elbow	
☐	Chest		☐	Foot		☐	Hand/fingers	

YES	NO	
yes	no	23. Have you ever had a stress fracture?
yes	no	24. Have you ever had a disc injury in your back?
yes	no	25. Has a doctor ever restricted your exercise because of an injury?
yes	no	26. Do you currently have any injuries that are bothering you?

27. Do you consider your occupation as?

- ☐ Sedentary (no exercise)
- ☐ Inactive-occasional light activity (walking)
- ☐ Active-regular light activity and/or occasional vigorous activity (heavy lifting,
- ☐ Heavy Work-regular vigorous activity

28. List your regular physical activities

Activity	How often do you do it?	How long do you do it?	How long ago did you start?

ADDITIONAL DETAILS:

APPENDIX E:

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

    _____ **days per week**

    ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

    _____ **hours per day**

    _____ **minutes per day**

    ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

    _____ **days per week**

    ☐ No moderate physical activities → ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking ➡ ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

Appendix F:

24-Hour History

ID ________
Treatment ________ Treatment # ________
Date ________ Time ________
USG ________ (not to be >1.030) Temp. ________ (not to be >37.8^{0}C)

1. How many hours of sleep did you get last night? (please circle one)
   1 2 3 4 5 6 7 8 9 10 11 12 >12

2. How many hours of sleep do you normally get? (please circle one)
   1 2 3 4 5 6 7 8 9 10 11 12 >12

3. How many hours has it been since your last meal or snack? (please circle one)
   1 2 3 4 5 6 7 8 9 10 11 12 13 >14

   List the items below:

4. When did you last have:
   · a cup of coffee or tea?

   · cigarettes?

   · drugs (including aspirin)?

   · alcohol?

   · herbal or dietary supplements?

5. How many 8 oz. glasses of water or other beverages have you consumed in the last 24 hours?
   1 2 3 4 5 6 7 8 9 10 11 12 13 14

6. When did you last consume water or another beverage? ____________How much? ________ (glasses)

7. What sort of physical activity did you perform yesterday?

8. What sort of physical activity have you performed today?

9. Describe how you feel right now by checking one of the following:

______excellent	______good	______very bad
______very, very good	______neither good nor bad	______very, very bad
______very good	______bad	______terrible

Appendix G:

RATING OF PERCEIVED EXERTION SCALE

6	
7	Very, Very Light
8	
9	Very Light
10	
11	Fairly Light
12	
13	Somewhat Hard
14	
15	Hard
16	
17	Very Hard
18	
19	Very, Very Hard
20	

APPENDIX H:

Thermal Perception (1-8 pt.)

0.0 Unbearably Cold
0.5
1.0 Very Cold
1.5
2.0 Cold
2.5
3.0 Cool
3.5
4.0 Comfortable
4.5
5.0 Warm
5.5
6.0 Hot
6.5
7.0 Very Hot
7.5
8.0 Unbearably Hot

Appendix I:

PAIN INTENSITY SCALE

0	**NO PAIN AT ALL**
½	**VERY FAINT PAIN (just noticeable)**
1	**WEAK PAIN**
2	**MILD PAIN**
3	**MODERATE PAIN**
4	**SOMEWHAT STRONG PAIN**
5	**STRONG PAIN**
6	
7	**VERY STRONG PAIN**
8	
9	
10	**EXTREMELY INTENSE PAIN (almost unbearable)**
•	**UNBEARABLE PAIN**

Appendix J:

DIET RECORD

Date of Record ____________ Subject # __________

Day of Week (circle): MON TUES WED THURS FRI SAT SUN

____

NOTE: Please be as specific as possible with recordings. Include detail about the meal such as the brand of the product and what the product is specifically called that you are consuming. If possible measure out amounts consumed. Measuring the volume of frequently used dishware such as cups and bowls is the easiest way to do this.

Meal	What Did You Eat? What Brand?	Amount	Cooking Method	Time of Day	Activity While Eating
Example	"Eggland's Best" Eggs	2 med.	Fried	7:30 a.m.	Talking w/friends
BREAKFAST	....	....	....	....	....

					…… …… …… …
SNACK	…………………………………… …………………………………… …………………………………… ……………………………………	…………… …………… …………… ……………	…………… …………… …………… ……………	…………… …………… …………… ……………	…… …… …… … …… …… …… … …… …… …… … …… …… …… …
LUNCH	…………………………………… …………………………………… …………………………………… ……………………………………	…………… …………… …………… ……………	…………… …………… …………… ……………	…………… …………… …………… ……………	…… …… …… … …… …… …… … …… …… …… …

SNACK					
DINNER					

					…… …… …… …
SNACK	……………………………………………… ……………………………………………… ……………………………………………… ………………………………………………	…………… …………… …………… ……………	…………… …………… …………… ……………	…………… …………… …………… ……………	…… …… …… … …… …… …… … …… …… …… … …… …… …… …