

UNIVERSITY OF WISCONSIN-LA CROSSE

Graduate Studies

TRAINING BENEFITS CONSEQUENT TO 8-WEEKS OF KETTLEBELL
TRAINING

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

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Clinical Exercise Physiology

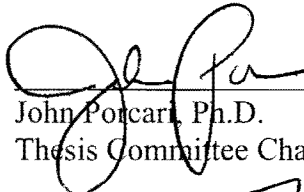
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By Nicholas M. Beltz


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

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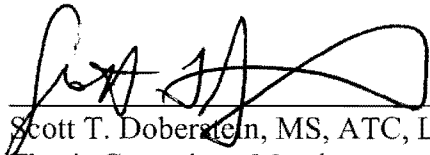
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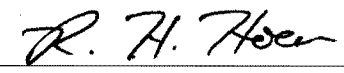
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ABSTRACT

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This study was designed to examine the changes in aerobic capacity and muscular strength consequent to 8 weeks of kettlebell training. Seventeen subjects (9 males, 8 females) completed 1 repetition maximum (1RM) testing for one-arm shoulder press, leg press, upright row, and handgrip strength. Subjects then performed an 8-minute kettlebell VO₂max snatch test to determine aerobic capacity. Testing was done before and after the 8-week training program. The 8-week kettlebell training program consisted of kettlebell snatches, swings, Turkish get-ups, and variations of the three fundamental movements. Each training session consisting of a 5-minute warm-up, 40 minute exercise session, and 10 minute cool-down. Following the training program, the experimental group demonstrated significant ($p < 0.05$) improvements in VO₂max (13.8%), leg strength (14.8%), and grip strength (13.9%) compared to the control group. No significant changes were found in the upright row or shoulder press between groups. The results show that an 8-week kettlebell training program is an effective way to improve muscular strength and aerobic capacity.

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INTRODUCTION

The Russians have long been viewed as pioneers in the realm of strength and conditioning and one of their earliest training regimes involved the use of kettlebells, which dates back to 1704. A kettlebell is a large, solid cast-iron sphere with a wide handle attached to its top. Kettlebells have been used for centuries to train Russian soldiers and law enforcement officers, and their use later developed into a competitive national sport. Kettlebells burst onto the American fitness scene in 2001 with Pavel Tsatsouline helping to pave the way for their popularity (Tsatsouline, 2001).

Anecdotally, those who train with kettlebells claim that it is a very intense workout. The training effect of kettlebells had been purely observational until Schnettler et al. (2009) demonstrated the vigorous nature of kettlebell exercise. Schnettler et al. found that heart rate (HR) and oxygen consumption (VO_2) responses during a 20-minute kettlebell workout averaged 93% of HRmax and 78% of VO_{2max} . These responses were consistent with the American College of Sports Medicine (ACSM) guidelines for improving cardiorespiratory endurance (ACSM, 2010). Similarly, Farrar et al. (2010) studied the intensity of a 12-minute kettlebell exercise protocol known as the “Man-Maker.” They found that the “Man Maker” workout produced HR and VO_2 training responses of 87% and 65% of maximal values, respectively. Jay et al. (2011) were the first to study the training effects of kettlebells on aerobic capacity and muscular strength. They

found that a 20-minute training session, 3 days per week for 8-weeks elicited a significant improvement in trunk extension strength, but did not elicit significant improvements in shoulder elevation strength, trunk flexor strength, and aerobic capacity.

Kettlebell training is similar to a training practice that has drawn large amounts of research attention. Circuit weight training (CWT) has been studied for decades and involves the completion of a series of moderate-weight resistance training exercises (40-70% of 1RM), alternated with rest periods of 30-60 seconds. The thought behind CWT is that by keeping rest periods short, heart rates will remain elevated and result in an aerobic training effect. Chtara et al. (2008) found that a 12-week CWT program significantly increased maximal muscular strength by 17%. The study also found greater muscular strength gains with CWT alone compared to a concurrent aerobic/strength training program. A study by Gettman et al. (1978) found that a 20-week CWT program not only produced muscular strength benefits, but also a 3.5% increase in VO_2max . Chtara et al. (2005) also performed a study to observe changes in aerobic capacity after a 12-week CWT program and found an average increase in VO_2max of 7.4%.

To our knowledge, there has only been one study on the muscular strength and aerobic training effects from kettlebell training. We felt that a study that provided a greater training load could provide additional information on the potential muscular strength and aerobic capacity training benefits of kettlebell exercise. The purpose of this study was to determine the effects of kettlebell training on aerobic capacity and muscular strength. This study was part of a

larger study that determined potential changes in balance, flexibility, and body composition consequent to kettlebell training.

METHODS

Subjects

Subjects for this study were 18 apparently healthy men and women recruited from the University of Wisconsin- La Crosse campus. Twelve volunteers with similar characteristics were used as a control group. All subjects had some background in weight lifting and were recreationally active. All subjects provided written informed consent prior to undergoing any testing or training procedures. Protocol was approved by the UW-L Institutional Review Board for the Protection of Human Subjects.

Testing Protocol

Testing for this portion of the study assessed VO₂max and muscular strength. All subjects underwent tests before and after the 8-week training protocol. A modified kettlebell snatch VO₂max test (Jay, 2011) was used to assess aerobic capacity. Subjects used 4.5, 8, 10, 12, or 16 kg kettlebells during the kettlebell test, depending upon individual experience level, strength, body weight, and gender. During the test, the subject started the first minute with their non-dominant hand and switched hands every minute until the test was completed. The testing protocol is defined below and was paced by a pre-recorded audiotape.

Kettlebell VO₂max test

- 1st minute: 6 reps/ 1 rep per 9 seconds

- 2nd minute: 7 reps/ 1 rep per 8 seconds
- 3rd minute: 8 reps/ 1 rep per 7 seconds
- 4th minute: 10 reps/ 1 rep per 6 seconds
- 5th minute: 12 reps/ 1 rep per 5 seconds
- 6th minute: 15 reps/ 1 rep per 4 seconds
- 7th minute: 20 reps/ 1 rep per 3 seconds
- 8th minute: Subject performed as many repetitions as possible until volitional fatigue.

During the test, HR was measured using a radio telemetry (Polar Electro, New York, USA) and oxygen consumption was measured using open circuit spirometry (Parvo Medics, Utah, USA).

Prior to the VO₂max test, all subjects participated in two kettlebell workouts. The purpose of these workouts was to familiarize subjects with correct kettlebell technique.

Muscular strength was determined for grip strength and 1-repetition maximum (1RM) on three different exercises. During the grip strength test, the subject performed three trials with their dominant hand using a Lafayette handgrip dynamometer (Lafayette Instrument Company, Indiana, USA, Model 32523). The highest value of the three trials was used in the analysis.

The three 1RM exercises used were a leg press using a hip sled, an upright row using a machine, and a one-arm shoulder press using a dumbbell. All subjects were familiarized with proper lifting technique and performed a warm-up set of 8 repetitions at ~50% of each individual's estimated 1RM prior to testing.

The weight was then increased and subject performed a single repetition at each weight. A rest period of 2-3 minutes was given to the subject between each weight and 1RM was defined when the subject was unable to lift the next highest weight. All 1RM tests were completed within six repetitions of finishing the warm-up phase.

Training

Certified kettlebell instructors led all the training sessions, which were held at the University of Wisconsin- La Crosse Recreational Eagle Center. Each participant performed the kettlebell workout 2 days per week for 8 weeks. Make up sessions were held on Saturdays. The training program consisted of a 5-minute active warm-up, 40-minute full body kettlebell workout consisting of core kettlebell exercises such as the swing, snatch, clean, press, and Turkish get-up, and a 10-minute cool-down period.

STATISTICAL METHODS

Independent t-tests were performed to identify pre-testing differences between the experimental and control groups. A 3-way (pre-post x group x gender) ANOVA with repeated-measures was used to determine differences consequent to the training period for each variable. When there was a significant F ratio, Tukey's post-hoc tests were used to make pairwise comparisons. Significance was set at an α level of 0.05 to achieve statistical significance. All analyses were conducted using the Statistical Package for the Social Sciences (SPSS, Version 19; SPSS Inc., Chicago, IL.)

RESULTS

Initially there were 18 subjects in the experimental group and 12 subjects in the control group. One female from the experimental group did not complete the study due to time commitments and one male in the control group could not complete the post-testing due to injury. Descriptive characteristics of subjects who completed the study are presented in Table 1. The experimental and control subjects were similar in age, height, and weight but were not matched controls. All subjects in the experimental group completed 16 training sessions.

Table 1. Descriptive characteristics of the subjects

Variable	Experimental	Control
Male (n)	9	5
Age (yrs)	22.1 ± 2.80	22.2 ± 2.28
Height (in)	70.0 ± 1.93	70.4 ± 1.78
Weight (lbs)	171.3 ± 23.94	176.1 ± 34.74
Female (n)	8	6
Age (yrs)	21.5 ± 3.93	21.2 ± 1.72
Height (in)	64.7 ± 2.25	64.9 ± 1.03
Weight (lbs)	142.3 ± 27.70	129.4 ± 9.19

Physiological responses to the kettlebell training are presented in Table 2.

There were no significant differences in the training responses of males and

females over the course of the study, thus whole group data are presented. The experimental group had significant improvements in VO₂max, leg press, and grip strength over the course of this study compared to the control group. The experimental group also had a significantly higher RER during post-testing compared to the pre-testing. There were no significant changes in HRmax or shoulder press in either group. The control group had a significant increase in upright row, however this improvement was not significantly different than the improvement in the experimental group.

Table 2. Physiological responses to kettlebell training in the experimental (n=17) and control (n=11) groups over the course of the 8-week study.

Variable	Pre	Post	Change
VO₂max (ml/kg/min)			
Control	37.5 ± 7.97	38.8 ± 7.49	1.3
Experimental	36.3 ± 5.42	41.3 ± 6.20	5.0 ^{*#}
Maximal Heart Rate (bpm)			
Control	179 ± 18.1	181 ± 16.9	2
Experimental	184 ± 13.8	190 ± 8.5	6
RER			
Control	1.08 ± 0.115	1.13 ± 0.106	0.05
Experimental	1.10 ± 0.105	1.24 ± 0.079	0.14 ^{*#}
Shoulder Press (lbs)			
Control	37.7 ± 15.47	39.6 ± 15.08	1.9
Experimental	44.7 ± 15.58	46.9 ± 13.93	2.2
Leg Press (lbs)			
Control	527.7 ± 210.74	539.6 ± 201.31	11.9
Experimental	619.7 ± 203.59	711.5 ± 229.04	91.8 ^{*#}
Row (lbs)			
Control	84.1 ± 24.98	91.6 ± 25.35	7.5 [*]
Experimental	89.7 ± 27.18	94.1 ± 26.23	4.4

Grip Strength (lbs)			
Control	40.1 ± 12.31	40.0 ± 13.05	-0.1
Experimental	41.7 ± 11.63	45.5 ± 12.17	5.8 ^{*#}

* - Significant change from pre-testing (p<0.05).

- Significantly different than change for control group (p<0.05).

Only one subject completed 15 of the 16 workouts wearing a Polar Heart rate monitor and his overall combined results are presented in Figure 1. Average intensity of the kettlebell workouts corresponded to 74.2%HRmax. Using a HR/VO₂ regression equation derived from this individual's pre-testing VO₂max test, it was determined that exercise intensity corresponds to 55.3% of VO₂max. Time spent within the 70-80% and 80-90% HRmax zones were 28.8% and 34.3%, respectively.

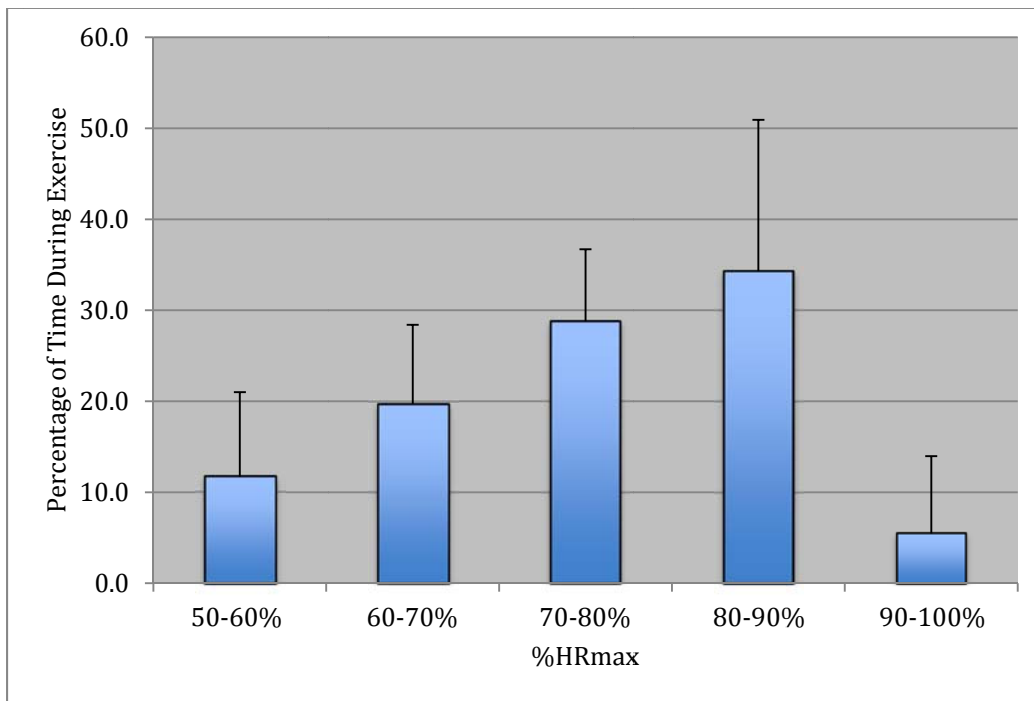


Figure 1. Average heart rate response for the kettlebell training sessions in a single subject.

DISCUSSION

The purpose of this study was to determine changes in aerobic capacity and muscular strength consequent to a twice weekly, 8-week kettlebell training program. It was found that aerobic capacity increased 13.8% in the experimental group after training. It is possible that some of this increase could be attributed to higher RER and maximal HR values recorded in the experimental group during the post-testing. Because they were more trained in the use of kettlebells after completing the 8 weeks of training, subjects may have been able to push themselves harder during the post-testing.

This increase in aerobic capacity is consistent with exercise intensity data from Schnettler et al. (2009) and Farrar et al. (2010). Schnettler et al. (2009) examined the intensity of a 20-minute kettlebell snatch workout and found that subjects exercised at an average of 93% of HRmax and 78% of VO₂max. Farrar et al. (2010) found that a 10-minute kettlebell swing routine known as the “Man Maker” elicited intensities of 87% of HRmax and 65% of VO₂max. In the current study, the average HR from one subject who wore a HR monitor during training found that he was working at 74.2% of HRmax and 55.3% of VO₂max, with approximately 40% of the exercise done above 80% of HRmax. Thus, it would appear that kettlebell training is within ACSM guidelines to improve cardiorespiratory endurance.

Our results do not agree with the findings of Jay et al. (2011). They found that an 8-week kettlebell training program did not elicit significant improvements in aerobic capacity. Several factors could explain the different results between studies. First, the duration of the training sessions in the study by Jay et al. were only 20-minutes in duration. This included a 5-10 minute warm-up and a 10-15 minute training period. Workout duration in the current study averaged 55 minutes and included a 5-minute warm up, a 40-minute conditioning period consisting of a variety of kettlebell exercises, and a 10-minute cool-down. Second, the current study used a kettlebell specific VO_2 max testing protocol to assess aerobic fitness. The study by Jay et al. used a submaximal bike test to measure aerobic capacity. It is likely that this test was not specific enough to detect potential changes in aerobic capacity after the kettlebell training.

Most people would consider kettlebell training to be a weight training exercise. A reason for the increase in aerobic capacity could be the full-body nature of the kettlebell exercises. Most kettlebell exercises require multi-joint movements from large muscle groups (e.g., snatches, cleans, Turkish get-ups). Recruiting more muscle mass in a dynamic, total body fashion leads to a higher metabolic overload compared to traditional weight training.

Kettlebell training also resulted in a 14.8% increase in leg strength and a 13.9% increase in grip strength. This suggests that even though a kettlebell workout is more aerobic in nature than traditional weight training, benefits in muscular strength were not compromised. There were no significant changes in shoulder press strength for either group. This finding was consistent with the data

from Jay et al. (2011), who did not find an increase in isometric shoulder elevation strength. However, Jay et al. (2011) did report a significant increase in back extensor strength, which was attributed to the force generated during the kettlebell swing.

In the current study, the control group had a significant increase in upright row strength; however, this increase was not significantly different than the increase seen in the experimental group. This difference suggests the presence of a learning response.

The increases in leg and grip strength with no increases in upright row and shoulder press are probably attributed to the nature of the kettlebell training. A majority of the movements started with the kettlebell on the ground and used the momentum of the kettlebell gained from hip and leg activation to finish above the head. Using the momentum to finish the movement puts little reliance on the back and shoulder muscles.

Kettlebell training incorporates exercises and techniques that are extremely unique, but are most similar to circuit weight training (CWT). CWT is a training regiment that utilizes a series of weight training exercises coupled with short rest periods in order to keep HR elevated. Keeping the HR high is thought to result in aerobic training benefits. Traditional CWT consists of 10-15 repetitions of 8-10 exercises, with 30-60 seconds of rests between exercises. Kettlebell training is similar to traditional CWT in that exercises are performed with resistance, followed by short intermittent rest periods.

Gettman and Pollock (1981) conducted a review of CWT training programs and found an average increase of 3.2% in running VO_2max . The 13.8% increase in VO_2 in the present study appears to be greater than those of a traditional CWT program. An explanation for this lies in the metabolic demand during CWT compared to kettlebell training. The metabolic demand of CWT has been well documented. Wilmore et al. (1978) observed that subjects were working at 84% of HRmax , but only 45% of VO_2max . Garbutt (1994) found that CWT elicited intensities of 69% of HRmax and 50% of VO_2max . Beckham and Earnest (2000) conducted a free-weight CWT program and found that subjects were working at an average of 60% of HRmax , but only 28.5% of VO_2max . The findings of Schnettler et al. (2009) and Farrar et al. (2010), coupled with the results of the current study, suggest that a kettlebell training session elicits a greater metabolic overload than traditional CWT. Compared to kettlebell training, HR is elevated disproportionately greater than VO_2 during CWT exercise. The explanation for this has been examined by Porcari and Curtis (1996) and is described as a pressor response.

Wilmore (1978) was the first study to examine strength changes consequent to a CWT program. Subjects improved by an average of 13.8% on leg press, 8.7% on shoulder press, and 8.1% on upright row. Gettman (1978) found a 43% increase in leg press and Chtara et al. (2005) reported an overall increase of 17% in leg strength using a half-squat. Gettman and Pollock (1981) reported an increase of 7-27% for leg press strength following a CWT program. A major reason for the difference in strength gains between kettlebell training and CWT

could be that this training program was limited to 8 weeks, which is at least 2 weeks shorter than most of the CWT studies. Additionally, this kettlebell training program was held 2 days per week, as compared to the typical 3 days per week used in most CWT studies. Another reason for the differences in strength gains between kettlebell training and CWT is that the amount of resistance used during the kettlebell training was not a set value determined by a pre-testing value, such as the 40-70% 1RM used in the CWT studies. The weight used by the kettlebell participants ranged from 4.5-24 kg and was chosen by the participant based upon individual comfort level. Also, subjects did not train the specific exercises that were used for the pre and post testing.

A limitation to this study was the availability of the space needed to train participants. Training was done in a multi-purpose room at the University Recreational Eagle Center, so training times and days were limited to 2 nights per week for 8 weeks. Even though all subjects attended 16 training sessions, minor orthopedic injuries and muscle soreness may have affected training intensity throughout the study. Another limitation to the study could have been the VO_2 max test used to determine physiological adaptations to kettlebell training. The VO_2 max test used was an 8-minute kettlebell snatch test. Although the snatch is a fundamental movement used in kettlebell training, it is only one of many different kettlebell exercises that could have been used.

CONCLUSION

In conclusion, an 8-week kettlebell training program is an effective way to elicit both aerobic and muscular strength benefits. Implementation of a kettlebell training routine can also add variety to any exercise training program.

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APPENDIX A
INFORMED CONSENT

INFORMED CONSENT

TRAINING BENEFITS CONSEQUENT TO 8 WEEKS OF KETTLEBELL EXERCISE

I, _____, volunteer to participate in a research study being conducted by the University of Wisconsin-La Crosse.

Purpose and Procedures

- The purpose of this study is to determine the fitness benefits resulting from 8 weeks of kettlebell training.
- Research assistants will be conducting the research under the direction of Dr. John P. Porcari, a Professor in the Department of Exercise and Sport Science.
- My participation in this study will involve the completion of a series of tests before and after the kettlebell training period. These tests will include:
 - A maximal aerobic capacity (VO₂max) test. For this test I will be asked to lift an individually prescribed kettlebell at an increasing rate until I can no longer continue. The test will start out at a slow pace and progressively increase each minute until I can no longer continue. During the test I will wear a chest strap to measure my heart rate and a face mask to analyze by expired air.
 - Maximal strength of my back and shoulders will be assessed using three different exercises; one will involve lifting as much weight as I can off of the ground, one will involve lifting as much weight as I can to shoulder height, and one lift will involve lifting as much weight as I can overhead with one hand.
 - My flexibility will be assessed with a sit-and-reach test where I will reach forward as far as possible while in a sitting position, and a back arch test where I will arch up as high as possible while lying face-down on the floor.
 - My balance will be assessed by balancing on one foot and reaching our as far as possible with the other foot, and also by standing on a platform that will determine how much my body “sways” as I try to stand still.
 - My body composition will be assessed using a series of skinfold measurements.
- For training, I will be asked to participant in an 8-week kettlebell training program. The program will be held at the La Crosse YMCA and be led by certified kettlebell instructors. Each class

will be approximately 60 minutes in length, including a warm-up and cool-down period.

- Total time commitment for this study will be approximately 24 hours, including all of the testing and training sessions.

Potential Risks

- I may experience muscle fatigue and muscle soreness as a result of completing the exercise tests and workouts used in the current study. Additionally, shortness of breath, irregularities in heart rhythm, heart attack, stroke, and even death are possibilities of vigorous exercise. However, the risk of serious or life-threatening complications is very low (<1/10,000 tests) in apparently healthy adults.
- All testing and training sessions will be stopped immediately if there are any complications.
- Individuals trained in CPR and Advanced Cardiac Life Support (ACLS) will be available during all testing sessions. Additionally, an Automatic External Defibrillator (AED) is available in both the testing and training sites.

Benefits

- As a participant in this study, I will learn by base level of aerobic fitness, strength, flexibility, balance, and body composition.
- As a result of the training sessions I will be participating in, it is reasonable to expect an improvement if at least some of the above measurements.

Rights and Confidentiality

- My participation in this study is entirely voluntary.
- I may choose to discontinue my involvement in the study at any time, for any reason, without penalty.
- The results of this study have the potential of being published or presented at scientific meetings, but my personal information will be kept confidential and only group data will be presented.

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

If I have any other questions that arise I may feel free to contact John Porcari, the principal investigator, at (608) 785-8684. Questions in regards to the protection of human subjects may be addressed to the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects at (608)785-8124.

Subject: _____ Date: _____

Investigator: _____ Date: _____

APPENDIX B

PHOTO OF SUBJECT PERFORMING KETTLEBELL SNATCH TEST



APPENDIX C
REVIEW OF LITERATURE

REVIEW OF LITERATURE

This review of literature covers research on kettlebell training as well as circuit weight training.

Exercise Recommendations

The American College of Sports Medicine (ACSM) clearly identifies the importance of regular physical activity and the health benefits associated with exercise (ACSM, 2010). The ACSM recommends that a healthy individual engage in at least 30 minutes of moderate-intensity aerobic exercise, at 40-60% of VO_2R or 64-74% of maximal heart rate (HRmax), 5 days per week. An alternative to the moderate-intensity recommendations is a workload of 20 minutes of vigorous-intensity exercise, >60% of VO_2R or 74-94% of HRmax, 3 days per week. It is also recommended that resistance-training be done 2-3 days per week. This program should consist of 2-4 sets of 8-12 repetitions focusing on multi-joint, large muscle group (chest, shoulders, back, hips, legs, abs) exercises. The concept of circuit weight training (CWT) has been studied since the 1970s and combines aerobic and resistance training components with the purpose of eliciting physiological responses similar to performing aerobic and resistance training independently.

Circuit Weight Training

Wilmore et al. (1978) were some of the original researchers who studied the effects of CWT. Their aim was to attempt to study different modes of exercise that could elicit benefits similar to bouts of jogging and resistance training. They examined the energy cost of CWT by having 20 men and 20

women within the age range of 17-36 years complete 3 circuits of 10 different stations at 40% of 1 repetition maximum (1RM). Each exercise was performed for 30 seconds and followed by 15 seconds of rest between stations. The protocol lasted 22.5 minutes with a 5-minute warm-up prior to testing and a 12-minute cool-down session post-testing. They found that men were working above 70% of HRmax, but below 45% of VO₂max. Similarly, women worked above 80% HRmax and below 50% of VO₂max. The large difference between HR and VO₂max responses was an interesting observation, which they attributed it to the upper-body dominant nature of the circuit training protocol. Wilmore et al. concluded that a bout of CWT has a similar oxygen cost to jogging at 5.0 mph or biking at 11.5 mph.

Wilmore et al. (1978) conducted another CWT study that examined the longitudinal effects of a 10-week CWT program. Variables examined were body composition, muscular strength, flexibility, and cardiovascular changes. Twenty-six college-aged men and 24 college-aged women performed 3 circuits of 10 different stations at 40-55% of 1RM. Each exercise was performed for 30 seconds and followed by 15 seconds of rest. The entire exercise bout lasted 22.5 minutes and the subjects completed this protocol 3 days per week for 10 weeks. Significant increases in lean body mass were found in both men and women and fat mass was significantly decreased in women. It was suggested that a study done over a longer period of time would most likely elicit greater changes in body composition. Men had a significant improvement in the time to exhaustion on a treadmill (24 seconds), while women had a significant increase in VO₂max

(10.7%), as well as treadmill time to exhaustion (5.8% increase). The explanation for the changes in $VO_2\text{max}$ in women as compared to men was that women worked at a greater percentage of $HR\text{max}$ and $VO_2\text{max}$ than men during the study. In terms of strength, men had significant improvements strength in the shoulder press, curl, lat pulldown, and knee flexion strength. This change represents four of the eight exercises tested. Women, however, saw improvements in each of the eight lifts.

Around the same time, Gettman et al. (1978) were also conducting research on training responses to CWT. They capitalized on the research by Wilmore et al. and suggested that a study done for 20 weeks would show even greater physiological improvements than a 10 or 12-week CWT program. Gettman et al. gathered 70 police officers ranging in age from 21-35 years. Subjects were divided into three different groups: CWT, continuous running (CR), and sedentary control. The exercise groups performed a 45-minute session 3 days/week with the first 15 minutes dedicated to a warm-up and the remaining 30 minutes to their respective activity. The CWT group performed 2 circuits of 10 exercises done at 50% 1RM with 30 seconds of rest between exercises. Repetitions per exercise gradually progressed from 10 to 20 reps during the first 6 weeks and were later reduced to 15 reps for the remaining 14 weeks. The study showed that CWT increased leg press and bench press strength by 43% and 26%, respectively. An increase in $VO_2\text{max}$ (3.5%) was also found.

Gettman and Pollock (1981) published a review article summarizing the effects of CWT. They reported an average change in relative VO_2 of 3.2% in men

and only a slight change for women. Changes in strength widely varied from study to study, but overall increases were seen. Changes in leg press increased anywhere from 7-27% using a 1RM test and there was a single case reporting a 48% increase, however a 10-rep maximal test was used to assess strength.

Garbutt et al. (1994) assessed the physiological responses to a single session of CWT. The session consisted of 3 circuits of 9 different resistance exercises. Load was set at 40% of 1RM; leg exercises were performed 15 times and arm exercises were performed 10 times with 30 seconds of rest between sets. They found that CWT elicited intensities of 69% of HRmax and 50% of VO₂max. This study was important because it further confirms the difference between %HRmax and %VO₂max during a CWT bout.

Beckham and Earnest (2000) conducted a study examining the metabolic cost of CWT with free weights rather than stationary machines. The rationale for this study was that a free weight CWT is considerably more space and cost efficient than traditional CWT programs. Also, free weights recruit more stabilizing muscles than stationary weight training machines. Subjects were 18 females and 12 males between the ages of 18-45 years. The CWT protocol utilized a 14-minute video called PowerFlex and used a weighted bar for resistance during exercise. Subjects followed along to the video using two different resistance loads; the standard 1.4 kg bar and a 5.9 kg load (bar plus weights) for women and 10.5 kg load for men. It was found that men worked at an average of 26.7% of VO₂max and 61.5% of HRmax while women averaged 30.3% of VO₂max and 58.5% of HRmax during a single bout of the PowerFlex

protocol. These results show that greater loads should be used during a CWT session to elicit intensities that can improve strength and provide cardiovascular benefits according to the ACSM.

Chtara et al. (2005) performed a study with the intention of evaluating changes in aerobic capacity between different types of training. One of the types of exercise studied was CWT. They studied 48 male college athletes over the course of a 12-week period. The 12-week period consisted of four, 3-week cycles performed 2 days per week. The CWT program in each cycle lasted 30 minutes and the circuits were performed four times during the CWT bout. Each bout had six exercises, but the work/rest periods differed depending on the cycle. Cycles 1 and 3 were 30 seconds work/30 seconds rest while Cycles 2 and 4 were 40 seconds work/20 seconds rest. Absolute and relative VO_2 max improved by 8.29% and 6.45%, respectively, over the 12-week training period.

A study by Chtara et al. (2008) examined changes in muscular strength and power development between different types of training. The subjects studied were 48 male college athletes who performed designated training protocols 2 days a week for 12 weeks. The CWT protocol was separated into four, 3-week periods. Periods 1 and 2 were strength endurance phases while Periods 3 and 4 were explosive strength and power phases. Circuits were completed five times and rest periods were 2-minutes, totaling 30 minutes per workout. Half-squat 1RM was used to assess strength changes and the 12-week CWT protocol elicited an increase in strength of 17%.

Kettlebell Training

Schnettler et al. (2009) studied the energy cost and relative energy intensity of a kettlebell training session. The subjects for this study included 10 adults that were experienced in using kettlebells. Each subject performed a treadmill VO_2 max test as well as a kettlebell-specific VO_2 max test. Subjects then performed a 20-minute kettlebell snatch workout. Results of the snatch workout showed an average intensity of 93% of HRmax and 78% of VO_2 max.

Farrar, Mayhew, and Koch (2010) completed a similar study to examine the oxygen cost of a single kettlebell exercise routine. This study included 10 college-aged men. These subjects completed a 12-minute kettlebell swing routine known as the “Man Maker.” Average intensity during the training session was 65.3% of VO_2 max and 86.8% of HRmax. The authors concluded that a 12-minute kettlebell training routine elicits greater metabolic demands than traditional CWT.

Jay et al. (2011) completed a study to examine the effectiveness of kettlebells on improving musculoskeletal and cardiovascular health. The study involved 40 men with occupations with a high prevalence of musculoskeletal pain symptoms. The experimental group performed ballistic full-body exercises 3 times per week for 8 weeks. Variables measured included pain intensity in the neck/shoulders, low back, isometric muscle strength, and aerobic fitness. The study found a decrease in neck/shoulder pain intensity of 2.1 points and a low back pain decrease of 1.4 points on the pain scale compared to the control group. Muscle strength of the trunk extensors increased significantly, but there were no significant changes in shoulder or back flexor strength. A submaximal test was

performed on a Monark cycle ergometer to estimate changes in aerobic fitness and it was found that there were no significant improvements.

McGill and Marshall (2012) performed a study with the intention of measuring spinal loads during different kettlebell exercises. Seven male subjects were used in the study and a single case study was done on an accomplished kettlebell master. The results of their study showed that compared to traditional bar lifting tasks, such as the deadlift, the kettlebell swing produced a greater shear force on the spine, as opposed to greater compression forces. It is felt that compression force is the main culprit for spinal disc injuries and training with a kettlebell may promote hip activation rather than spinal activation while performing lifts. It was also found that carrying a kettlebell in the “bottoms up” position challenges the core musculature as compared to a traditional carrying technique.

Summary

Very little research has been done on kettlebell training, however kettlebell training is most similar to CWT. Kettlebell training appears to elicit a higher %HRmax and %VO₂max compared to CWT. Another unique characteristic of kettlebell training may be the benefits in lower back health.

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