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The Effects of Kettlebell Training on Aerobic Capacity

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THE EFFECTS OF KETTLEBELL TRAINING ON AEROBIC CAPACITY

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ABSTRACT

THE EFFECTS OF KETTLEBELL TRAINING ON AEROBIC CAPACITY

by J. Asher Falatic

The purpose of this study was to determine the effects of a kettlebell training program on aerobic capacity. Seventeen female NCAA Division I collegiate soccer players (age 19.7 $\pm$ 1.0 years, height 166.1 $\pm$ 6.4 cm, weight 64.2 $\pm$ 8.2 kg) completed a graded exercise test to determine maximal oxygen consumption (VO_2max). Participants were placed into a kettlebell intervention (KB) group (*n* = 9) or a circuit weight training control (CWT) group (*n* = 8). Participants in the KB group completed a kettlebell snatch test to determine individual snatch repetitions. Both groups trained 3 days per week for 4 weeks in addition to their off-season strength and conditioning program. The KB group performed the 15:15 MVO_2 protocol (20 min of kettlebell snatching with a 15 s work-to-rest ratio). The CWT group performed multiple free weight and dynamic body weight exercises as part of a continuous circuit program for 20 min. The 15:15 MVO_2 protocol significantly increased VO_2max in the KB group. The average increase was 2.3 $ml \cdot kg^{-1} min^{-1}$, or approximately a 6% gain. There was no significant change in VO_2max in the CWT control group. Thus, the 4-week 15:15 MVO_2 kettlebell protocol, using high intensity kettlebell snatches, significantly improved aerobic capacity in female intercollegiate soccer players.

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Chapter 1

Introduction

In the past decade, kettlebell training has gained popularity and become a viable option for strength training and conditioning. Hailing from Russia, it is believed to be an efficient way to increase muscular strength, muscular endurance, aerobic capacity and to reduce body fat (Farrar, Mayhew, & Koch, 2010). A kettlebell can be described as an iron cannonball with a broad handle attached to it (Schnettler, Porcari, & Foster, 2010). It is a unique training tool that allows one to exercise in ways different from traditional dumbbells or barbells.

Kettlebells are an ideal tool for ballistic, full-body exercises using high muscle forces, making them potentially useful for improving muscular strength and cardiorespiratory fitness (Jay et al., 2010). One exercise, the kettlebell snatch, develops cardiorespiratory endurance and has considerable carryover to physical activities such as running and jumping (Tsatsouline, 2006). In his book, *Viking Warrior Conditioning*, Master Russian kettlebell® instructor Kenneth Jay (2009) presents an aerobic conditioning protocol that utilizes high-intensity kettlebell snatch intervals designed to improve maximal oxygen consumption, or VO_2max . Dubbed the 15:15 MVO_2 protocol, it involves multiple sets of 15 s of kettlebell snatching alternating with 15 s of rest. Schnettler et al. (2010) determined the energy cost and relative intensity of this particular kettlebell workout. They found that when performing 20 min of the 15:15 MVO_2 protocol, average heart rate was 93% of maximum and oxygen consumption was 78% of VO_2max. According to the American College of Sports Medicine (ACSM), exercise intensities between 77 and 90% of maximal heart rate or above 40-50% of oxygen uptake reserve are sufficient to improve cardiorespiratory fitness (Thompson, Gordon, & Pescatello, 2010). Thus, the 15:15 MVO_2 protocol should improve aerobic fitness and thus increase VO_2max.

Statement of the Problem

Cardiorespiratory endurance is recognized as one of the fundamental components of physical fitness, while VO_2max is an important factor determining aerobic performance (Helgerud et al., 2007). It has been shown that higher exercise intensities elicit greater improvements in VO_2max than lower exercise intensities (Gormley et al., 2008). High intensity interval training (HIIT) requires working at or near maximal intensity for short periods of time. Studies by Helgerud et al. (2007) and Thomas, Adeniran, and Etheridge (1984) revealed that interval running at 90-95% of maximal heart rate (HRmax) improved VO_2max in untrained and moderately trained individuals more than training at 70-80% of HRmax. Similarly, Tabata et al. (1996) and Graef et al. (2009) showed that individuals who performed HIIT programs on a cycle ergometer at supramaximal intensities (120-170% of VO_2max) increased their aerobic capacity more than individuals who performed low intensity, continuous work. Enhancing aerobic endurance through HIIT can also lead to improvements in athletic performance. After 4 weeks of HIIT, well trained rowers significantly improved their 2000 m times (Driller, Fell, Gregory, Shing, & Williams, 2009) while cyclists improved their 40 km time trials (Laursen, Shing, Peake, Coombes, & Jenkins, 2005). Additionally, Helgerud, Engen, Wisloff, and Hoff (2001) found that improving soccer players' aerobic capacity through HIIT led to enhancements in multiple variables of soccer performance.

Unfortunately, there is a limited amount of evidence-based research examining kettlebells and their potential cardiorespiratory benefits. In one of the few studies on the subject, Farrar and colleagues (2010) found that performing 12 min of continuous kettlebell swings provided a metabolic challenge of sufficient intensity (87% of HRmax and 65% of VO_2max) to increase VO_2max more than traditional circuit weight training. Jay et al. (2010) conducted a randomized control trial examining the effects of kettlebell training on musculoskeletal pain symptoms and VO_2max. Participants performed kettlebell swing progressions 3 days a week for 8 weeks. Results showed significant reductions in neck and shoulder pain, as well as low back pain when compared to an inactive control group; however, there was no change in VO_2max. The few studies examining the effects of kettlebells on cardiorespiratory fitness have produced equivocal results. A possible reason may be that training intensities have varied from moderate to high. Schnettler et al. (2010) found during one exercise session that the 15:15 MVO_2 protocol elicits adequate intensities to improve VO_2max. Yet, there are no studies that show that kettlebell training can improve aerobic capacity over time. Further investigation into this topic is a necessity as kettlebells are becoming an increasingly popular training tool.

Statement of the Purpose

The purpose of this study was to determine the effects of a kettlebell training program on aerobic capacity, or VO_2 max. There are no studies that show kettlebell training can improve aerobic capacity over time. A circuit training program served as the control during the 4-week intervention.

Hypotheses

The purpose of this study was to determine if a specific kettlebell training program improved VO_2max in female soccer players. Players were assigned to the kettlebell (KB) or circuit weight training control (CWT) groups. The null hypothesis was that after the 4-week training period, there would be no difference in VO_2max gains between the KB and CWT groups. Alternate hypothesis 1 was that after the training period, the KB group would have a greater gain in VO_2max than the CWT group. Alternate hypothesis 2 was that after the training period, the KB group would have less gain in VO_2max than the CWT group.

Delimitations

All participants were on the roster of a NCAA Division I collegiate women's soccer team. Participants had to be at least 18 years old to participate in this research study. Prior to pretesting, all participants were free of any upper or lower body injury that would keep them from participating in physical activity and/or competition. Participants assigned to the KB group demonstrated safe and efficient technique when performing the kettlebell snatch. Proper technique was needed to minimize the risk of injury. This was demonstrated by correctly bracing the abdominals and shoulder throughout the exercise to help protect the lower back and shoulder complex, as well as correctly activating the posterior trunk extensors.

Limitations

Possible limitations to this study included the participants' willingness to exercise at high intensity levels, exercise outside of the team's practice and conditioning, and variations in the amount of practice and conditioning of individual players. Other limitations included the participants' diet and body weight throughout the intervention period. An increase or decrease in body weight would affect the participants' relative VO_2.

Definitions

In this study, the KB group followed the 15:15 MVO_2 protocol created by Kenneth Jay (2009) and presented in *Viking Warrior Conditioning*. It was defined as multiple sets of 15 s of kettlebell snatching separated by 15 s of rest. The 15:15 MVO_2 protocol was used as the kettlebell intervention in this study.

A kettlebell snatch is a dynamic exercise performed with a kettlebell. During the snatch, the kettlebell travels from between an individual's legs to a lockout position above the head (Jay, 2009). This is the foundation exercise of the 15:15 MVO_2 protocol.

Summary

Despite a limited amount of literature, kettlebell training has the potential to improve aerobic capacity if the exercise intensity is sufficient (Farrar et al., 2010). HIIT has been shown to significantly improve VO_2max in untrained and well-trained individuals (Graef et al., 2009; Helgerud et al., 2007; Tabata et al., 1996; Thomas et al., 1984). The 15:15 MVO_2 protocol incorporates both high intensity interval training and kettlebells. A recent study by Schnettler et al. (2010) showed that one exercise session of the 15:15 MVO_2 elicited an exercise intensity sufficient to improve VO_2max. There are only a handful of studies that have examined the cardiorespiratory response to kettlebells. Moreover, there are no studies that show that kettlebell training can improve aerobic capacity over time. Therefore, the purpose of this study was to determine the effects of a kettlebell training program on aerobic capacity.

Chapter 2

Review of Literature

Kettlebells and kettlebell training as a research topic are still a novel idea. Literature regarding kettlebell training is scarce. However, the kettlebell intervention in this study uses high intensity interval training. Therefore, this review will examine kettlebell training and the effects of HIIT on VO_2max and athletic performance.

Kettlebell Training

Kettlebells have been around for many years and are native to Russia. They are routinely used by the Russian military Special Forces to build muscle, increase strength, and improve cardiorespiratory endurance (Tsatsouline, 2006). A kettlebell can be described as a cannonball with a handle (Schnettler et al., 2010). Kettlebells are gaining popularity in this country and are being used in different strength and conditioning programs (Farrar et al., 2010). However, there is a lack of evidence-based literature concerning the effectiveness of kettlebells as a training modality. Presently, most information on kettlebells can be found in books, training manuals, and online forums. There are only a handful of peer-reviewed, kettlebell research articles available in the United States. More attention to this growing research area is needed.

In one of the few studies examining the effects of kettlebells, Farrar et al. (2010) documented the cardiorespiratory demands of a particular kettlebell protocol. The purpose of this study was to investigate the heart rate response and oxygen cost of performing the "US Department of Energy Man Maker," a kettlebell exercise protocol designed to increase cardiorespiratory fitness. Ten college-aged males were recruited to perform as many kettlebell swings as possible with a 16 kg kettlebell for 12 continuous minutes. The initial test session established the participant's baseline VO_2max from a treadmill running test using the Bruce protocol and a metabolic cart that measured expired gases. During the second test session, participants performed the "Man Maker" while heart rate and oxygen consumption were recorded each minute. The mean intensity of the exercise bout was 65.3 $\pm$ 9.8% of VO_2max. Mean heart rate was 165 $\pm$ 13 bpm, or 86.8 $\pm$ 6.0% of HRmax. Based on guidelines set by the ACSM, the heart rate and VO_2 maintained during the 12 min kettlebell exercise were sufficient to improve cardiorespiratory fitness (Thompson et al., 2010). These values are greater than the oxygen consumption and heart rate values previously found in circuit weight training (Farrar et al., 2010). Therefore, this kettlebell exercise protocol required a metabolic demand of sufficient intensity to improve cardiorespiratory fitness.

In one of the first randomized control studies examining the effects of kettlebell training on musculoskeletal pain symptoms and aerobic fitness, Jay et al. (2010) implemented a workplace resistance intervention consisting of a four kettlebell exercise progression for a group of 40 participants with neck and low back pain. The participants were relatively inactive individuals who worked long hours at a desk or computer and had no previous kettlebell experience. The intervention consisted of kettlebell swings, with and without a kettlebell, kettlebell deadlifts, and single arm kettlebell swings. Participants performed each exercise 10 times with 30 s to 1 min rest between sets, 3 days per week for 8 weeks. Progression was individually based and involved increasing kettlebell weight or number of repetitions per set. The kettlebell intervention significantly decreased pain intensity in the neck/shoulder and low back and significantly increased back extension strength when compared to an inactive control group. Using Åstrand's standardized method to estimate VO_2max from a submaximal workload, there was no change in VO_2max in the intervention group.

VO_2max Snatch Protocol. Kenneth Jay, a Master Russian kettlebell instructor, describes in his book, *Viking Warrior Conditioning*, how individuals can train their cardiorespiratory system and improve VO_2max by utilizing several kettlebell exercise protocols that he developed (Jay, 2009). These protocols involve specific work-to-rest ratios of kettlebell snatching at high intensities (at or near VO_2max) for extended periods of time. Work-to-rest intervals allow a high work intensity to be maintained throughout the entire exercise. This places a significant demand on both the aerobic and anaerobic metabolic pathways. The kettlebell snatch is a common exercise used by those who regularly train with kettlebells. According to Paval Tsatsouline, a kettlebell expert and founder of the Russian Kettlebell Certification®, the kettlebell snatch develops outstanding cardiorespiratory endurance and has considerable carryover to physical activities such as running and jumping (Tsatsouline, 2006). It is a dynamic and explosive exercise that involves multiple muscle groups. During the snatch, the kettlebell travels from between an individual's legs to a lockout position above the head. This motion is reversed and repeated at a rapid pace, increasing the velocity that the kettlebell travels. As velocity increases, power output increases, resulting in a higher caloric expenditure and oxygen consumption (Jay, 2009).

Before the Viking Warrior Conditioning protocol can be started, a cadence test ($cMVO_2$) must be performed to determine the kettlebell snatch repetition number. The $cMVO_2$ involves a 5 min test in which the snatch cadence increases every minute:

1st minute: 10 repetitions per minute or 1 repetition per 6.0 s

2nd minute: 14 repetitions per minute or 1 repetition per 4.2 s

3rd minute: 18 repetitions per minute or 1 repetition per 3.3 s

4th minute: 22 repetitions per minute or 1 repetition per 2.7 s

5th minute: As many repetitions as possible in 1 min

With each minute, the tested person switches arms. The repetition number achieved in the fifth minute is needed to calculate the interval snatch cadence for the selected protocol, such as the 15:15 MVO_2 protocol (Jay, 2009).

The 15:15 MVO_2 protocol calls for a 15 s work-to-rest ratio (15 s of high intensity work followed by 15 s of rest) throughout an established duration. The number of repetitions achieved in the fifth minute of the $cMVO_2$ test is divided by 4. This determines the interval snatch cadence that will be used in every 15 s work interval throughout the exercise protocol (Jay, 2009). For example, if 24 repetitions are achieved in the final minute of the $cMVO_2$, then the 15:15 MVO_2 snatch cadence is 6 for every 15 s work interval. Thus, 6 repetitions of single arm snatches must be performed during every 15 s work interval throughout the exercise duration. A 15 s rest interval follows every work interval, and participants switch arms after every rest interval. This allows the intensity to be maintained at or near 100% for the entire workout. The exercise duration can be adjusted; however, a high intensity must be maintained during each 15 s work interval (Jay, 2009).

A recent study by Schnettler et al. (2010) examined physiological responses to the $cMVO_2$ test and the 15:15 MVO_2 protocol. The main purpose of this study was to determine the energy cost and relative intensity of the two kettlebell workouts. Eight males and 2 females were recruited to take part in three phases of testing. Participants performed treadmill testing using the Bruce protocol to determine maximal heart rate and oxygen consumption. On separate testing days, participants performed the $cMVO_2$ kettlebell snatch test and the 15:15 MVO_2 snatch protocol. Heart rate and oxygen consumption were measured. Maximal oxygen consumption during treadmill testing was 23% higher than the mean VO_2 during the $cMVO_2$ test. During the 15:15 MVO_2 snatch protocol, heart rates and VO_2 were 93% and 78% of maximal values, respectively. These results fall within the ACSM guidelines for improving cardiorespiratory fitness (Thompson et al., 2010), suggesting that performing the 15:15 MVO_2 workout for 20 min could enhance aerobic capacity. The 15:15 MVO_2 snatch protocol places a substantial demand on both the oxidative and nonoxidative metabolic pathways (Schnettler et al., 2010).

High Intensity Interval Training

Maximal oxygen consumption is one of the most important factors determining cardiorespiratory fitness (Helgerud et al., 2007). Traditional endurance training, characterized by large work volumes of continuous running or cycling at a moderate intensity, has long been utilized to improve VO_2max. HIIT programs, on the other hand, require working at or near maximal intensity for shorter periods of time. Higher exercise intensities elicit greater changes in VO_2max than lower intensities (Gormley et al., 2008). When total work and training frequency are matched, higher intensity leads to larger improvements in VO_2max (Helgerud et al., 2007). HIIT has been shown to be comparable to and, in some cases, better than traditional endurance training for improving aerobic capacity (Graef et al., 2009; Helgerud et al., 2007; Tabata et al., 1996; Thomas et al., 1984).

Thomas et al. (1984) investigated the effects of multiple training protocols on VO_2max in untrained men and women. In this study, 59 people were randomly assigned to one of four exercise groups: a 4 mile continuous run at 75% of HRmax, a 2 mile continuous run at 75% of HRmax, an 8 set interval of a 1 min run at 90% of HRmax followed by 3 min of active rest, and a no exercise control. Each group completed the assigned exercises 3 days a week for 12 weeks; VO_2max was measured before and after the 12 week training program. Only the interval group showed a statistically significant improvement in VO_2max compared to the control. The authors concluded that a high intensity interval running program can improve cardiorespiratory fitness in untrained populations.

Similarly, Helgerud et al. (2007) conducted a study to compare different training intensities matched for energy expenditure. Forty moderately trained males were randomly assigned to one of four groups: a continuous run at 70% of HRmax for 45 min (LSD), a continuous run at 85% of HRmax for 24.25 min (LT), a sprint interval consisting of 47 repetitions of 15 s of running at 90-95% of HRmax followed by 15 s of active rest at 70% HRmax (15:15), and a 4 set interval of 4 min of running at 90-95% of HRmax followed by 3 min of active rest at 70% of HRmax (4 x 4). Each group trained 3 days a week for 8 weeks. Results showed significant increases in VO_2max and stroke volume in the 15:15 and 4 x 4 groups following training compared to LSD and LT groups. The increases in stroke volume corresponded to the increases in VO_2max, signifying a close relationship between the two. Thus, HIIT was more effective at improving VO_2max than high volume, continuous exercise (Helgerud et al., 2007). These results are consistent with Gormley et al. (2008) who also showed that when the volume of exercise is controlled, higher intensities improve VO_2max more than lower intensities. In this study, 55 participants were separated into a moderate (50% VO_2 reserve), vigorous (75% VO_2 reserve), near VO_2max intensity (95% VO_2 reserve), or no exercise group and completed a progressive 6 week training protocol. The duration of exercise sessions was calculated to match work volumes for all groups. Each exercise group progressively increased exercise frequency and duration throughout the 6 week training period. All exercise groups significantly increased VO_2max, with greater aerobic improvements in the higher intensity groups.

Tabata et al. (1996) investigated the aerobic and anaerobic effects of continuous endurance training and HIIT in recreationally active males. In experiment one, 7 males completed a continuous endurance training program 5 days a week for 6 weeks. The participants performed continuous exercise on a bicycle ergometer for 60 min at 70% of VO_2max. In experiment two, 7 different males, also moderately active, performed 7 to 8 sets of 20 s of high intensity work (170% of VO_2max) on a bicycle ergometer for the same frequency and duration as the participants in experiment one. Each 20 s work interval was followed by 10 s of rest. Both programs increased VO_2max, although only the HIIT program increased anaerobic capacity. The 6 week HIIT program improved participants' VO_2max by 7 $ml \cdot kg^{-1} min^{-1}$ and anaerobic capacity by 28%. The continuous endurance training program increased VO_2max by 5 $ml \cdot kg^{-1} min^{-1}$. In this study, anaerobic capacity was defined as the maximal accumulated oxygen deficit during a 2 to 3 mile exhaustive bicycle test. The authors concluded that both training programs increased maximal oxygen consumption, although HIIT concurrently improved aerobic and anaerobic capacities.

Graef et al. (2009) investigated the effects of a 4-week HIIT program and creatine supplementation on cardiorespiratory fitness. Forty-three males were randomly placed in a creatine group (Cr), a placebo group (Pl), or a control group. The control group did not participate in any exercise during the 4-week period. The Cr and Pl groups completed the same HIIT program, consisting of 5 sets of 2 min of exercise on a bicycle ergometer with 1 min rest intervals between sets. They exercised 5 days a week, with 3 of the 5 days at higher intensities. Exercise intensities ranged from 80 to 120% of VO_2peak as the training program progressed. The investigators found that the 4-week HIIT protocol significantly increased VO_2peak and time to exhaustion at VO_2peak in both the Cr and Pl groups.

Training adaptations become increasingly difficult to obtain as individuals become highly trained. In order to compete at high levels, it is imperative that athletes achieve a high level of fitness. Improvements in performance for well trained athletes become difficult to achieve even when training volumes increase (Driller et al., 2009). In addition to increasing VO_2max, recent studies have also shown that HIIT improves athletic performance in well-trained athletes.

Driller et al. (2009) found that HIIT increased endurance performance in highly trained individuals. Ten well trained rowers (5 females and 5 males) completed a 4-week HIIT program and a 4-week continuous moderate work training program (CT) in a crossover design. Rowers were randomly placed into either the HIIT or CT group for the first 4 weeks of training. After the initial 4 weeks, participants switched training groups and completed another 4 weeks of training. During the HIIT program, participants performed 8 work intervals at 90% of their velocity at VO_2peak for 2.5 min. Each work interval was separated by a rest interval that required the heart rate to return to 70% of HRmax. The CT protocol consisted of 60 min of work on a bicycle ergometer at workloads corresponding to a blood lactate concentration of 2 to 3 mM. After 4 weeks of HIIT, 2000 m rowing time and power significantly improved compared to the CT intervention. This study was one of the first to show that HIIT programs can significantly improve performance in well trained rowers (Driller et al., 2009).

Similarly, Laursen et al. (2005) found that well trained cyclists can benefit from HIIT. In this study, 38 cyclists with 3 or more years of cycling experience were tested in multiple performance tests and a time-to-exhaustion test. They then underwent a 4-week HIIT training program, exercising 2 days a week on a bicycle ergometer. Participants were placed into one of four training groups. Group 1 performed eight 1:2 work-to-rest intervals at VO_2peak power output for a duration corresponding to 60% of their time to exhaustion. Group 2 followed the same protocol as group 1, but rest periods were based on the time for heart rate to return to 65% of HRmax. Group 3 performed twelve, 30 s sprints at 120% of peak power output with 4.5 min rest between bouts. Group 4 was the control group that performed a low intensity exercise program. After the training period, HIIT groups 1 through 3 showed significant improvements in 40 km time trials and peak power output (Laursen et al., 2005). Only group 1 and 2 showed significant improvements in VO_2peak compared to the control group. It is evident that a 4-week HIIT program can significantly improve both anaerobic and aerobic capacities in well trained cyclists, and is associated with an improvement in cycling performance (Laursen et al., 2005).

Helgerud et al. (2001) investigated the effects of aerobic endurance training on performance in elite junior soccer players. Nineteen soccer players from two elite junior soccer teams participated in this study. Nine players were assigned to a training group and 10 to the control. The training intervention consisted of four, 4 min running intervals at 90 to 95% of HRmax, separated by jogging intervals at 50-60% of HRmax. The intervention program was performed in addition to the seasonal workout routine 2 days a week for 8 weeks. After the 8 week training period, VO_2max increased by 10.8%, lactate threshold increased by 16%, and running economy increased by 6.7%. Video analysis of the participants' competitive matches showed that the trained group increased total distance covered by 20%, number of sprints per player by 100%, and number of involvements with the ball by 24.1% (Helgerud et al., 2001). Increases in these variables ultimately improved the athletic performance of the high-intensity, interval trained, soccer players.

Circuit Weight Training

Circuit weight training (CWT) is a strength and conditioning protocol that incorporates multiple forms of resistance exercise in a predetermined succession (Haennel, Teo, Quinney, & Kappagoda, 1989). It can be characterized by utilizing light resistances and short rest periods that result in a relatively high cardiovascular demand and lactate concentration during the short duration of the workout program (Gotshalk, Berger, & Kraemer, 2004). Typically, CWT is performed by using free weights or fixed weight machines to isolate small muscle groups. However, performing continuous multijoint and multiplanar resistance exercises that mimic movements in sports can potentially elicit a greater aerobic effect than traditional CWT through the continual use of larger muscle groups (Lagally, Cordero, Good, Brown, & McCaw, 2009).

An early study by Haennel et al. (1989) showed that the cardiovascular effects of CWT are comparable to those of cycling. Thirty-two male participants were placed into one of four groups: a no exercise control group, two different CWT groups that utilized multiple hydraulic exercise machines, or a bicycle exercise group. The CWT groups differed in the number of repetitions performed, with one group performing the maximum number of repetitions per exercise and the other group performing 70-80% of maximal repetitions per exercise. Participants exercised 27 min a day, 3 days a week for 9 weeks. Results showed significant increases in VO_2max for all exercise groups ($p < .05$). The investigators attributed this to significant increases in stroke volume ($p < .05$).

In contrast, Beckham and Earnest (2000) investigated the acute aerobic effects of CWT. They found that using light and moderate resistance during a free weight circuit training session did not elicit sufficient cardiorespiratory stimulus to improve aerobic capacity. Twelve males and 18 females participated in this study. Each participant performed a treadmill stress test to measure VO_2max. Participants then completed two randomly assigned, videotaped free weight CWT programs with light or moderate resistance. Results showed that both CWT sessions required considerably lower oxygen consumption (< 30% VO_2max) than the minimal 40-50% of VO_2reserve recommended for improving aerobic fitness (Thompson et al., 2010).

Monteiro et al. (2008) investigated the acute physiological effects of two different CWT protocols. Ten males and 15 females were placed in a traditional CWT program and a combined CWT program that included weight training and treadmill running. The traditional CWT program consisted of 60 s work bouts at each exercise, while the combined CWT program consisted of 30 s of resistance training and 30 s of treadmill running. Each program had 15 s rest bouts between each exercise. The combined CWT program required greater relative and absolute $VO_{2,}$ and calorie expenditure compared to the traditional CWT program ($p < .05$). Additionally, compared to males, females worked at a significantly greater percentage of VO_2max in both the traditional and combined CWT programs. The authors concluded that a CWT program that combines bouts of running, such as the one in this study, can provide an efficient stimulus for improving cardiorespiratory fitness in both males and females.

Summary

Exercise intensity is an important variable in exercise prescription. Higher exercise intensities are more effective at improving VO_2max than low to moderate intensities. High-intensity interval running and cycling protocols have been shown to significantly improve aerobic capacity. Additionally, HIIT can improve athletic performance in well trained individuals. Circuit weight training has also been used to improve aerobic capacity. More recently, kettlebell training has been shown to elicit exercise intensities sufficient to increase VO_2max. The 15:15 MVO_2 kettlebell snatch protocol utilizes HIIT to elicit high exercise intensities that have the potential to increase VO_2max similar to that of high-intensity sprint and cycling protocols. However, there are few studies using kettlebells, and most have measured the acute effects of a single kettlebell training session. One study examined the effect of an 8 week kettlebell training program on aerobic capacity in relatively inactive individuals who did not have previous experience with kettlebells (Jay et al., 2010). The exercises included kettlebell swings and deadlifts, which are appropriate exercises for beginners. Although the program increased back extension strength, there was no change in aerobic fitness, measured using a submaximal test.

Chapter 3

Methods

The purpose of this study was to determine the effects of a kettlebell training program on aerobic capacity. The kettlebell protocol (15:15 MVO_2) that was used is described in Kenneth Jay's book, *Viking Warrior Conditioning*, and is explained in this chapter. To assess aerobic capacity, VO_2max was measured during a graded exercise test on a bicycle ergometer. Eighteen female collegiate soccer players were recruited as participants and were assigned to either the KB group or CWT group. Athletes in the KB group implemented a kettlebell protocol as part of an off-season workout, while athletes in the CWT group followed a typical strength and conditioning program. Kettlebell training was conducted 3 days per week for 4 weeks. Maximal aerobic capacity was assessed before and after the 4-week program to determine the aerobic effects of the kettlebell intervention. This chapter presents information on the participants, instrumentation, procedures, research design, and data analysis for this study.

Participants

Participants were recruited from a population of 21 female NCAA Division I collegiate soccer players. Prior to measuring VO_2max at the beginning of the study, two players sustained significant injuries that disqualified them as participants. Between the pre-VO_2max and the $cMVO_2$ tests, another participant sustained an injury that disqualified her from participation. Ten participants were selected for the KB group. They were free of any upper and lower extremity injuries that would prevent them from participating in physical activity and/or competition. This was assessed by a Board of

Certification (BOC) Certified Athletic Trainer (ATC). Additionally, to reduce the risk of injury, participants in the KB group exhibited proper technique for a kettlebell snatch. This was demonstrated by correctly bracing the abdominals and shoulder throughout the exercise to help protect the lower back and shoulder complex as well as correctly activating the posterior trunk extensors. This was assessed by a Russian Kettlebell Certified Strength and Conditioning Specialist (RKC/CSCS). The eight participants not selected for the intervention group were placed in the CWT group. All participants frequently trained with kettlebells as part of their seasonal strength and conditioning program, although the kettlebell snatch was not an exercise routinely implemented.

Instrumentation

Aerobic capacity was measured using an Ultima metabolic cart and a Lode Excalibur electronic cycle ergometer (both from Medical Graphics Corp., St. Paul, MN). Heart rate and rhythm were monitored from a 12-lead electrocardiogram (ECG). Blood pressure (BP) was measured manually with a blood pressure cuff, sphygmomanometer, and stethoscope. The Borg 6-20 scale was used to assess the participants' perceived exertion during the VO_2max test. Participants used Russian kettlebells® (12 kg) during the kettlebell snatch test and intervention protocol. Russian kettlebells are trademarked by Dragon Door (St. Paul, MN) as the most authentic and original kettlebells available. A Gym Boss (St. Clair, MN) interval timer was used to maintain the KG group's work and rest intervals during the training intervention. Work and rest intervals were set at 15 s. Polar heart rate monitors were used to measure heart rates during the 4-week KB and CWT programs.

Procedures

Approval was obtained from San José State University's Institutional Review Board. All participants provided written consent and an updated medical history prior to testing. Within the year, all participants had undergone a medical examination and were cleared for athletic participation by the team's ATC and physicians. During the testing and training sessions, the same ATC was present.

Testing procedures. There were two testing sessions prior to the start of the training program. During the first testing session, weight and height were measured using a platform scale (Accu-weigh, San Francisco, CA) and stadiometer, respectively. Weight was measured to the nearest 0.1 kg. Height was measured to the nearest mm. Electrode sites for the 12-lead ECG were cleaned by using an abrasive pad and alcohol. Standard placement for the six chest electrodes (V1 to V6) was used. Arm electrodes were placed just below the clavicle, and leg electrodes were placed just below the rib cage. Seat height was adjusted parallel to the participants' greater trochanter while standing next to the cycle ergometer. Resting BP and ECG were recorded while seated on the ergometer. Participants were connected to the metabolic cart via an air-tight facemask fitted with a pneumotach and sampling line. Ventilation, and oxygen and carbon dioxide concentrations in the expired air were measured with each breath. Participants selected a comfortable pedaling rate and were encouraged to maintain that rate throughout the test. Following a 2 min unloaded warm-up, resistance increased by 25 W each minute until the participant could not continue. Blood pressure was measured every 2 min during the graded exercise test (GXT), and ratings of perceived exertion

(RPE) were obtained each minute. Participants were considered to have achieved a maximal effort if two of the following criteria were met: A heart rate within 12 beats per minute (bpm) of age-predicted maximal heart rate, calculated as 207 – (0.7 x age in years); a respiratory exchange rate (RER) $\geq$ 1.10, or a RPE $\geq$ 17 (Thompson et al., 2010). All participants completed the first testing session within 6 days. The same GXT protocol was repeated after the 4-week training period to evaluate aerobic training effects.

During the second testing session, individual kettlebell snatch repetition numbers were determined for participants in the KB group. A continuous 5 min kettlebell snatch procedure was used, with the snatch cadence increasing every minute. Participants used a 12 kg Russian Kettlebell® to perform their snatches. Time and snatch cadence were monitored by the investigator and strength coach. Prior to testing, participants had a 5 min warm-up period performing kettlebell swings at their own intensity. During each minute of the test, participants were instructed to switch arms, with the dominant arm starting the test. During the first minute, participants performed 10 snatches, or 1 snatch every 6.0 s. Snatch cadence increased each successive minute. During the second, third, and fourth minutes, participants performed 14, 18, and 22 snatches, respectively. This corresponded to a snatch cadence of 1 snatch every 4.2, 3.3, and 2.7 s, respectively. During the fifth minute, participants performed as many kettlebell snatches as possible. The number of kettlebell snatches achieved by each participant in the fifth minute was divided by 4. The resulting number represented the kettlebell repetitions performed during each 15 s work interval of the kettlebell training intervention.

Training procedures. After completing all pretesting, participants continued their off-season strength and conditioning program under the supervision of the RKC/CSCS. At the time of the study, participants had already completed 4 weeks of the hypertrophy phase of their periodized strength program. Much of the program was focused on the hips and legs, with standard linear periodization progressions for traditional resistance training. All volumes and load assignments fell under hypertrophy-specific adaptations. Each resistance session lasted approximately 1 hr. Following each resistance session, the soccer team finished each training session with aerobic/anaerobic cardiovascular training. The training week consisted of 4 days of on-the-field work. Mondays were heavy aerobic days that repeated each week. Tuesdays consisted of a mix of aerobic and anaerobic, soccer-specific skill drills. Thursdays were a speed day involving very high anaerobic sprint bouts. Fridays were programmed for game play. To keep their soccer skills refined, the athletes were divided into two teams for scrimmages. Independent of the KB and CWT interventions, training was rigorous, and players were intentionally placed under significant amounts of fatiguing work.

Both the KB and CWT groups followed the same resistance training routine. The 20 min KB or CWT protocols were performed between the strength training and on-the-field training sessions. The KB group performed a kettlebell snatch protocol while the CWT group performed a circuit workout consisting of multiple free weight and body weight exercises. Participants performed the KB or CWT intervention on Mondays, Tuesdays, and Thursdays in weeks 1, 2, and 4. In week 3, participants completed the intervention sessions on Tuesday, Thursday, and Friday due to schedule changes.

Participants in the KB group performed the 15:15 MVO_2 kettlebell snatch protocol with 15 s work and rest intervals using a 12 kg kettlebell. For every 15 s work interval, participants performed their individual snatch cadences that were calculated on the second day of testing. They were instructed to perform their snatches as fast as possible. Each 15 s work interval was followed by a 15 s rest interval. Participants were instructed to begin with their dominant arm and switch arms with each 15 s work interval. This was repeated for 20 min, although the total work time was 10 min. The KB group was supervised and encouraged by the main investigator and RKC/CSCS to work as hard as possible.

The CWT group performed different free weight and dynamic body weight exercises as part of a circuit during the 20 min training sessions. The circuit incorporated multiple muscle groups and was developed by the RKC/CSCS. Participants completed five exercises in succession (1 set), and a total of 5 sets. Total work time was 10 min. The five exercises included 20 ball squats, 20 sit ups, 10 windmills, 10 jump squats, and a 400 m sprint/run. Participants performed ball squats and jump squats by deep squatting to a medicine ball, using only the participants' body weight. During jump squats, participants jumped explosively out of the deep squat position. Windmills were performed by side bending while stabilizing a 12 kg kettlebell overhead. Because this exercise did not involve ballistic movements with the kettlebell, it was not classified as kettlebell training in this study. The CWT group was supervised and encouraged by the main investigator and RKC/CSCS to work as hard as possible

Research Design

This study was experimental with pre and postmeasurements. The 15:15MVO_2 kettlebell snatch protocol was used as the kettlebell intervention. The effect of this protocol on aerobic capacity was examined and compared to a CWT group. Participants who missed 25% or more of the training sessions (3 or more of the 12 training sessions) were excluded from data analysis. There were no exclusions due to absence as all participants completed at least 75% of the training sessions.

Data Analysis

Descriptive statistics (means and standard deviations) were calculated for age, height, weight, and pre and post VO_2max values. A two-way repeated measures ANOVA was planned to evaluate differences in VO_2max between the KB and CWT groups over time. The alpha level was set at $p < .05$ to determine statistical significance. However, the normality assumption for the two-way repeated measures ANOVA was not met; thus, four t-tests were used to examine differences between groups and over time. Because of this, the pre-set alpha level was adjusted to $p < .0125$.

Chapter 4

Results

Twenty-one NCAA Division I female soccer players were eligible to participate in the study. Prior to testing, two participants failed to meet the inclusion criteria because of injuries. One participant was injured after completing the pretest and did not complete the posttest. Additionally, one participant in the KB group completed the pretesting and training sessions before sustaining an injury. She was cleared to participate 3 days before posttesting; however, during the posttest she reported symptoms 10 min into the GXT and the test was stopped before she reached maximal effort. Because of this, her data were excluded from the analyses. Thus, data are reported for 17 participants, 9 in the KB group and 8 in the control group. Demographic data are reported in Table 1.

Table 1

Demographic Data

	CWT Group (*n* = 8)	KB Group (*n* = 9)	All Participants (*N* = 17)
Age (yrs)	19.5 (1.1)	19.9 (1.1)	19.7 (1.0)
Height (cm)	161.7 (5.5)	170.1 (4.3)	166.1 (6.4)
Weight, pre (kg)	59.9 (3.4)	68.1 (9.4)	64.2 (8.2)
Weight, post (kg)	59.9 (3.4)	67.2 (8.9)	63.8 (7.6)

Note. Values are means (SD).

Initially, to examine differences in VO_2max between the KB and CWT groups over time, a two-way repeated measures ANOVA was planned. However, the normality assumption was not met; thus, four t-tests were used, and the preset alpha level was adjusted to $p < 0.0125$. As shown in Table 2, there was no significant difference in VO_2max values between the KB and CWT groups before the intervention, $t(15) = 1.027$, $p = .321$. Similarly, there was no significant difference in VO_2max values between the KB and CWT groups after the intervention, $t(15) = -0.299$, $p = .769$. The 4-week intervention did not significantly increase VO_2max in the CWT group, $t(7) = -0.253$, $p = .808$. However, the 4-week intervention did significantly increase VO_2max in the KB group, $t(8) = -3.482$, $p = .008$. The average increase was 2.3 $ml \cdot kg^{-1} min^{-1}$, or approximately a 6% gain. Additionally, the change in VO_2max was compared between the CWT and KB groups. The data did not meet the normality assumption for a *t* test; thus, the difference in median values between the groups was examined using a Mann-Whitney Rank Sum Test. The median change for the CWT and KB groups was 0.15 and 2.1 $ml \cdot kg^{-1} min^{-1}$, respectively, Mann-Whitney U statistic = 58.0, $p = .038$. Thus, the increase in VO_2max for the KB group was significantly greater than the increase in the CWT group.

Table 2

VO_2max Values for the Control and Kettlebell Groups

	CWT Group (n = 8)		KB Group (n = 9)	
	$ml \cdot kg^{-1} min^{-1}$	$L \cdot min^{-1}$	$ml \cdot kg^{-1} min^{-1}$	$L \cdot min^{-1}$
Pre VO_2max	37.8 (3.1)	2.257 (0.141)	36.2 (3.2)	2.448 (0.209)
Post VO_2max	38.1 (2.5)	2.278 (0.178)	38.5 (3.9)*	2.563 (0.142)
Change, Pre to Post	0.3 (2.9)	0.021 (0.183)	2.3 (2.0)	0.115 (0.150)

Note. Values are means (SD). *p = .008 compared to pre VO_2max.

Therefore, the 4-week intervention increased VO_2max in the KB group, but not in the CWT group. Kettlebells can be used as a training modality within a high-intensity, interval training program to improve aerobic capacity in female collegiate soccer players.

Chapter 5

Discussion

This study examined the effects of a 4-week kettlebell training program on aerobic capacity. The kettlebell training program used the 15:15 MVO_2 protocol described by Jay (2009). This protocol uses high intensity kettlebell snatches. Each 15 s work bout is followed by 15 s of rest, for a total duration of 20 min (10 min of exercise and 10 min of rest). Three training sessions were held each week over a 4-week period. Participants in the CWT group performed a circuit workout consisting of free weight and body weight exercises for the same exercise duration. In contrast to the 0.3 $ml \cdot kg^{-1} min^{-1}$ increase in VO_2max in the CWT group, the KB group gained 2.3 $ml \cdot kg^{-1} min^{-1}$, or a 6.4% increase in maximal aerobic capacity. When expressed relative to body weight, gains in VO_2max may result from an increase in muscle oxidative capacity or a loss of body weight. There was no change in body weight for the CWT group over the 4-week intervention; however, the KB group lost an average of 0.9 kg. The average gain in absolute VO_2max for the KB group was 0.115 $L \cdot min^{-1}$, which represents a 4.7% increase. Thus, the increase in maximal aerobic capacity in the KB group was primarily due to an increase in muscle oxidative capacity, rather than a loss of body weight during the 4-week intervention. The results support the first alternate hypothesis that the KB intervention would result in a greater improvement in VO_2max than the CWT intervention.

The present study is one of the first to investigate the effects of kettlebell training. Previous studies have measured HR and VO_2 responses during a single kettlebell exercise session, and results have indicated that the intensity was sufficient to improve cardiorespiratory fitness (Farrar et al, 2010; Schnettler et al., 2010). However, Jay et al. (2010) found no gain in aerobic capacity after an 8 week progressive kettlebell program. Participants in the Jay et al. study were relatively inactive and had no previous kettlebell experience. The kettlebell exercises included swings and deadlifts. In contrast, participants in the present study were intercollegiate athletes who regularly trained with kettlebells. Participants selected for the KB group demonstrated safe and efficient technique when performing the kettlebell snatch, a high intensity, dynamic exercise. Schnettler et al. (2010) reported that HR was 93% of HRmax and VO_2 was 78% of VO_2max during the 15:15 MVO_2 snatch protocol used in this study. Although the present study used a 4-week training program compared to the 8 week program used by Jay et al. (2010), the exercise intensity was likely much greater. The 15:15 MVO2 protocol is a high intensity workout with 15 s rest intervals between each 15 s work bout. In contrast, Jay et al. (2010) used a progressive kettlebell program with 3 sets of 10 repetitions, and a 30-60 s rest between sets. Results from the present study are consistent with research showing that higher exercise intensities elicit greater improvements in VO_2max (Gormley et al., 2008; Helgerud et al., 2007). Additionally, Helgerud et al. (2001) found that improving VO_2max in soccer players enhanced their on-field performance by increasing total distance covered, number of sprints, and number of involvements with the ball.

Training with kettlebells is becoming increasingly popular. Thus, future studies in this area are clearly needed. Understanding the acute responses and long term physiological adaptations to kettlebell training is crucial. Specifically, additional research is needed to evaluate the effects of kettlebell training on aerobic and anaerobic metabolism, strength and power development, and sport performance.

Limitations

Because this study used the kettlebell snatch, a dynamic and advanced kettlebell exercise, these findings should only be generalized to individuals who are trained and have experience using kettlebells. The CWT group in this study performed a circuit weight training program for the same duration as the KB group. In contrast to the KB group, the CWT group did not show a significant gain in VO_2max. This could be due to a difference in exercise intensity and total work, as both of these variables were not directly calculated or compared. Physical activity, in addition to the KB or CWT interventions and regular off-season workout program, was not controlled or documented. Additional exercise could potentially affect VO_2max measured after the 4-week intervention. Although the KB group increased VO_2 max, the training duration was only 4 weeks. A longer training program may result in greater aerobic adaptations. Finally, the number of participants in the KB and CWT groups was small, which reduced the power to detect a change in the CWT group. The power to detect a change in VO_2max was 5% for the CWT group compared to 84% for the KB group.

Practical Application

Kettlebells are a unique and practical option for strength training and conditioning. Athletes who use kettlebells in their exercise program can potentially increase aerobic capacity in a short amount of time by using the 15:15 MVO_2 kettlebell protocol. This protocol may also be used during injury rehabilitation. Athletes who have sustained a lower extremity injury that warrants little to no impact can perform this protocol as an alternative to maintain cardiovascular fitness. The kettlebell snatch is a low impact, dynamic exercise that also provides sufficient resistance for muscle strengthening, in addition to enhancing cardiovascular fitness.

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Appendix A

Raw Data

Participant	Group (n = 10)	Age	Ht	Pre Wt	Post Wt	Pre VO_2max	Post VO_2max
101	KB	20	173.2	59.9	60.2	35.3	40.9
103	KB	20	174.8	77.9	71.8	32.9	34.9
106*	KB	21	157.5	54.4	53.9	39.7	37.6
107	KB	21	166.1	69	70	33.7	35.8
108	KB	19	170.2	57.7	5.9	40.4	44.8
109	KB	18	170.7	57.9	57.9	38.6	41.1
115	KB	19	165.9	69.5	68.1	38.5	41.1
116	KB	20	166.4	66.7	65	36.6	38.7
117	KB	21	166.4	68.4	67.4	39	37.4
118	KB	21	177.3	86.3	86.5	31	32.2
Participant	**Group (n = 8)**						
102	CWT	20	163.6	57.2	57.5	38.2	35.9
104	CWT	19	162.8	64.4	64.7	36.3	36.6
105	CWT	19	170.2	63.7	64.4	36.6	36.8
110	CWT	21	154.7	55.9	58.5	44.7	42.7
112	CWT	19	155.4	60.4	60	38.5	36.3
113	CWT	18	159.8	61.8	58.3	35.5	36.8
114	CWT	19	167.6	59.8	60.8	34.5	41.2
119	CWT	21	159.3	55.7	54.9	38.1	38.2

Note. KB = kettlebells, CWT = circuit weight training; age in years, height in cm, weight in kg, VO_2max in $ml \cdot kg^{\cdot -1} min^{-1}$. *Participant 106 became symptomatic during posttest (11 days postinjury). Data were not included in statistical analyses.