Original Research

Cardiovascular and Metabolic Demads of the Kettlebell Swing using Tabata Interval versus a Traditional Resistance Protocol

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ABSTRACT

International Journal of Exercise Science 7(3) : 179-185, 2014. Tabata (TAB) training, consisting of eight cycles of 20 seconds of maximal exercise followed by 10 seconds of rest, is time-efficient, with aerobic and anaerobic benefit. This study investigated the cardiovascular and metabolic demands of a TAB versus traditional (TRAD) resistance protocol with the kettlebell swing. Fourteen young (18-25y), non-obese (BMI 25.7±0.8 kg/m^2) participants reported on three occasions. All testing incorporated measurements of HR, oxygen consumption, and blood lactate accumulation. Each participant completed Tabata kettlebell swings (male- 8kg, female- 4.5kg; 8 intervals; 20s maximal repetitions, 10s rest). On a subsequent visit (TRAD), the total swings from the TAB protocol were evenly divided into 4 sets, with 90s rest between sets. Outcome measures were compared using paired t-tests. The TAB was completed more quickly than the TRAD protocol (240.0±0.0 v. 521.5±3.3 sec, $P<0.01$), at a higher perceived exertion (Borg RPE; 15.1±0.7 v. 11.7±0.9, $P<0.01$). The TAB elicited a higher average VO_2 value (33.1±1.5 v. 27.2±1.6 ml/kg/min, $P<0.01$), percent of VO_{2peak} achieved (71.0±0.3 v. 58.4±0.3%, $P<0.01$), maximal HR (162.4±4.6 v. 145.6±4.8 bpm, $P<0.01$), and post-exercise blood lactate concentration (6.4±1.1 v. 3.7±0.5 mmol/L, $P<0.01$). **Conclusion:** The kettlebell swing demonstrated significantly greater cardiovascular and metabolic responses within a TAB vs. TRAD framework. Appropriate screening and risk stratification are advised before implementing kettlebell swings.

KEY WORDS: High-intensity interval training, heart rate

INTRODUCTION

The American College of Sports Medicine (ACSM) defines approximately 55% of maximal heart rate (HRmax) or 40% of oxygen uptake reserve (VO2R) as the minimal threshold of aerobic training benefit, or more commonly known as 'moderate-intensity' exercise (10). For maintaining cardiovascular health, at least 150 minutes a week of moderate-intensity aerobic activity is recommended (10), while 60-75 minutes of vigorous-intensity (>70% HRmax, >60% VO2R) aerobic activity can be substituted (6, 10). Since a lack of time is a common barrier to exercise participation (4), shorter duration high-intensity interval training (HIIT) protocols are promising. High-intensity interval training workouts, which use brief intervals of maximal (and even supramaximal) efforts, are more time-efficient than either the recommended 150 minutes of moderate- or 60-75 minutes of vigorous-intensity training, with comparable aerobic benefit (11).

Tabata et al. reported that individuals performing a 4-minute HIIT protocol involving 8 sets of supramaximal cycling (170% VO2max; 20s work/10s rest), demonstrated similar increases in aerobic performance when compared to individuals performing 60 minutes of moderate-intensity (70% of VO2max) endurance training over an identical six-week training period (12). In contrast to traditional moderate-intensity aerobic training, the 'Tabata interval' group also showed a significant 28% increase in anaerobic performance (12). Further work by this group confirmed that this interval was superior to other interval protocols using longer rest periods in taxing both the anaerobic and aerobic energy systems (13). While the 'Tabata interval' has gained popularity, there remains a very small amount of literature related to the safety and effectiveness of HIIT training using the Tabata protocol (1).

Likewise, kettlebells have become popular in the fitness community despite a fairly small number of scientific studies that have examined their safety and effectiveness (8, 9). This is particularly true in relation to cardiovascular and metabolic demand; however, brief (10-12min) kettlebell training sessions have been shown to elicit cardiovascular demand sufficient to enhance aerobic capacity (6). The traditional kettlebell swing may be an ideal exercise for a HIIT framework due to its full-body integration, high mechanical demand, and relative safety with proper form maintenance (8, 9, 14).

Therefore, the purpose of this study was to compare the acute metabolic and cardiovascular effects of the kettlebell swings exercise with a Tabata interval versus a protocol using high-repetition sets with long rest periods. It was hypothesized that the Tabata interval would elicit a greater metabolic and cardiovascular demand than a matched-volume traditional protocol.

METHODS

Participants

This study was approved by the Institutional Review Board at Delaware State University prior to data collection. Fourteen young (18-25y), non-obese volunteers were recruited from the Department of Public and Allied Health Sciences at Delaware State University. Each completed an informed consent document, Physical Activity Readiness Questionnaire (PAR-Q), and medical history questionnaire prior to participation. All participants had partaken in resistance training $\geq$2/week for six months or more, but had no previous experience with the kettlebell swing exercise.

Protocol

On the initial screening visit, participants were measured for height (cm; Seca 222 wall-mounted stadiometer, Seca, Birmingham, UK) and weight (kg; Tanita TBF-300A, Tanita Corporation of America, Inc., Arlington Heights, IL) in workout attire without shoes. Body mass index (BMI; kg/m^2) was calculated and participants were excluded from the study if they fell above the normal or overweight range (>29.9 kg/m^2). Body composition was assessed using air-displacement plethysmography (BODPOD system, Life

Measurement, Inc., Concorde, CA) according to manufacturer's specifications (3). Resting blood pressure and heart rate were measured according to standardized procedures, and participants were excluded if these values were outside of accepted ACSM healthy criteria (10). There were no participants screened who did not meet the study criteria.

Peak aerobic capacity (VO_{2peak}) was assessed with a continuous treadmill exercise stress test. Each subject's expired respiratory gases (Cosmed Quark CPET; Cosmed, Rome, Italy), heart rate (Polar HR monitor; Polar Electro Inc., Lake Success, NY), and rating of perceived exertion (RPE; Borg 6-20 scale) were collected and measured during the completion of an exhaustive treadmill protocol. Each participant began the treadmill test at a speed of 3.5 mph with a 0% grade. At two-minute intervals, the treadmill speed was increased (2-4min= 5.5 mph; 4-6min= 6.5mph; 6-8min= 7.5mph) until minute eight, where speed was maintained at 7.5mph.Treadmill grade was increased by 2.5% every two minutes until the subject reached volitional fatigue. Following screening, each individual received instruction in the proper technique and execution of the kettlebell swing. Female participants performed all of their swings with a 4.5kg kettlebell, while male participants used an 8kg kettlebell.

A repeated measures design was utilized, wherein participants reported for two experimental conditions: a Tabata (TAB) and traditional (TRAD) kettlebell exercise protocol. All participants completed the TAB condition first, in accordance with study design, with conditions separated by at least three days in order to allow adequate recovery. During both conditions, investigators collected expired respiratory gases, heart rate, and RPE, in accordance with the procedures outlined in the screening criteria. In addition, measures of blood lactate were collected immediately pre- and post-exercise, as well as one-minute post-exercise using the fingerstick method (Lactate Plus analyzer; Nova Biomedical Corporation, Waltham, MA).

The TAB protocol consisted of four minutes of kettlebell swings completed in eight consecutive sets at a twenty-second work to ten-second rest ratio (12). Participants were instructed to complete as many repetitions as possible during each twenty-second work interval, and place the kettlebell on the floor during rest. Immediate HR and RPE responses were recorded at the end of each work interval. Upon completion of the eighth set of work, the subject was immediately seated for blood lactate measurements. The total number of repetitions from the TAB protocol were calculated, and recorded for use during the TRAD protocol.

The TRAD protocol consisted of four sets of work separated by ninety seconds of rest. The total number of swings from each individual's TAB condition was equally divided into four sets for their TRAD condition. Immediate HR and RPE responses were recorded at the end of each work interval. Again, upon completion of the fourth set of work, lactate measurements were taken.

Statistical Analysis
All statistical analyses were performed with SPSS for Windows, version 18.0 (SPSS, Inc., Chicago, USA), and all data are reported as mean ± standard error of the mean. Oxygen

consumption values during experimental conditions are reported both as VO_2 (ml/kg/min), as well as the percentage of VO_{2peak} achieved during exercise. Comparisons were made between experimental conditions using paired-samples t-tests, while comparisons between male and female characteristics were made using independent samples t-tests. Significance levels in all statistical tests were accepted at □=0.05.

RESULTS

Male participants (n=10) were taller (177.5±2.0 v. 162.5±6.0 cm; P<0.05) and heavier (81.7±3.0 v. 66.5±6.9 kg; P<0.05) than their female counterparts (n=4). While there was no difference in BMI between males and females (26.0±1.0 v. 25.0±1.7 kg/m^2; P>0.05), male participants were leaner (15.5±2.0 v. 25.5±4.2 % body fat; P<0.05). There were no differences noted between conditions in pre-exercise heart rate (69.2±3.1 v. 68.2±3.3 bpm, P>0.05), systolic blood pressure (115.9±1.5 v. 117.1±5.4 mmHg; P>0.05), or diastolic blood pressure (69.3±2.4 v. 69.0±2.0 mmHg; P>0.05). On average, the TAB protocol was completed in less than half of the time as the matched-volume TRAD protocol (240.0±0.0 v. 521.5±3.3s; P<0.01). Additionally, participation in TAB was perceived as harder (Figure 1, Borg RPE; 15.1±0.7 v. 11.7±0.9; P<0.01) than the TRAD protocol.

Physiologically, the TAB condition produced a significantly higher VO_2 (33.1±1.5 v. 27.2±1.6 ml/kg/min; P<0.01) and greater percentage of VO_{2peak} (Figure 2; 71.0±0.3 v. 58.4±0.3%; P<0.01) than the TRAD protocol. Maximal heart rate values reached during exercise were also significantly higher in the TAB condition (Figure 3; 162.4±4.6 v. 145.6±4.8 bpm; P<0.01). Similarly, both immediate (Figure 4; 6.4±1.1 v. 3.7±0.5 mmol/L; P<0.01) and one-minute post-exercise lactate concentrations (Figure 4; 5.7±0.9 v. 3.4±0.5 mmol/L; P<0.01) were higher during the TAB protocol.

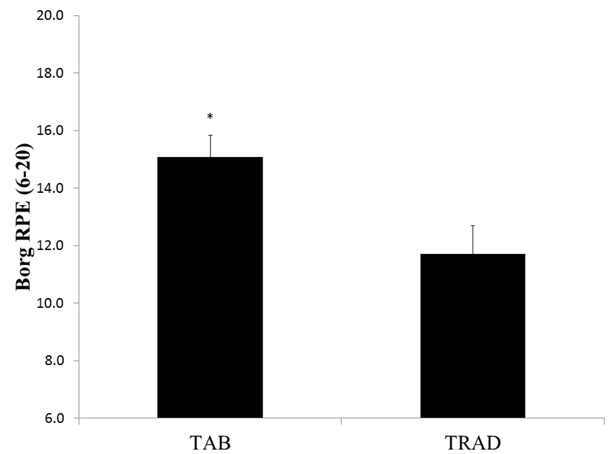

Figure 1: Subjective Borg RPE response to Tabata versus traditional kettlebell swing protocols in healthy, young adults. TAB- Tabata, TRAD- traditional. *Significantly greater than TRAD condition (P<0.01).

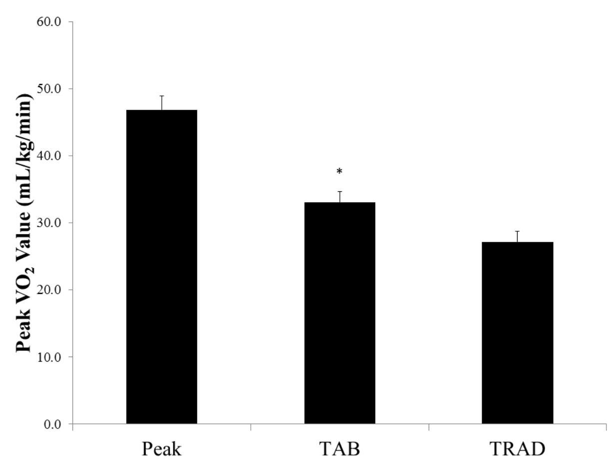

Figure 2: Percentage of peak VO_2 value achieved during Tabata and traditional kettlebell swing protocols in healthy, young adults. Peak- Peak VO_2 on aerobic capacity test, TAB- Tabata, TRAD- traditional. *Significantly greater than TRAD condition (P<0.01).

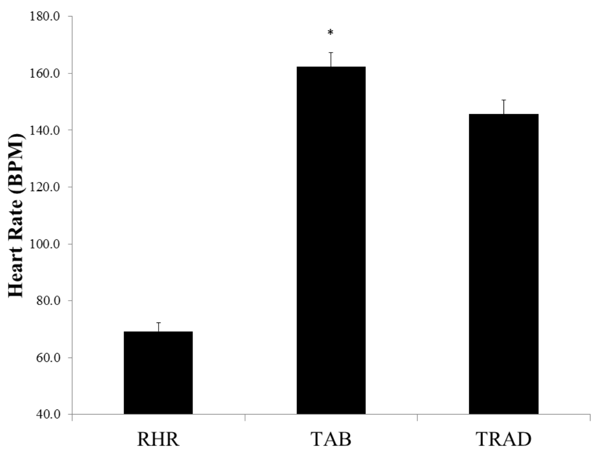

Figure 3: Heart rate response to Tabata and traditional kettlebell swing protocols in healthy, young adults. RHR- resting heart rate, TAB- Tabata, TRAD- traditional. *Significantly greater than TRAD condition (P<0.01).

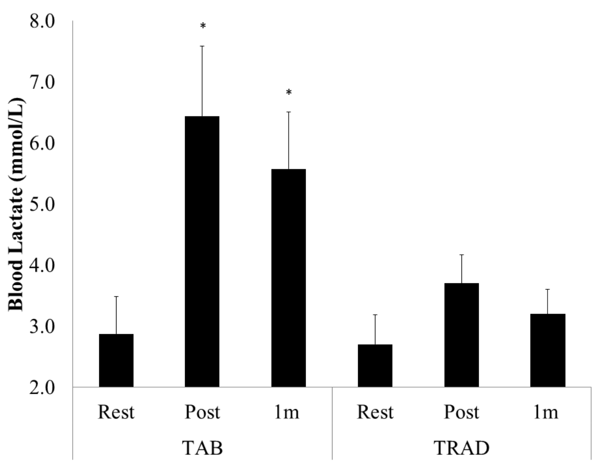

Figure 4: Comparison of the immediate and one-minute post-exercise blood lactate responses to Tabata and traditional kettlebell swing protocols in healthy, young adults. TAB- Tabata, TRAD- traditional, Post- immediate post-exercise, 1m- one-minute post-exercise. *Significantly greater than TRAD condition (P<0.01).

DISCUSSION

This study examined the metabolic and cardiovascular responses of the kettlebell swing exercise during a HIIT (Tabata interval) or traditional resistance training protocol. When an identical volume of kettlebell swings were compared, the TAB protocol demonstrated evidence of a greater exercise stimulus than the TRAD protocol.

A small number of well-designed studies have begun to characterize the unique biomechanical properties of the kettlebell swing exercise (8, 9, 14). Zebis and colleagues (14) reported that this rapid and rhythmic exercise produces a supramaximal level of resistance in the posterior chain, often exceeding values measured during a maximal voluntary contraction. Despite measuring similarly high levels of force in posterior chain musculature, another recent study (8) uncovered a distinctive characteristic of the loading pattern in the kettlebell swing related to the direction of shear forces on the lumbar vertebrae, reinforcing anecdotal reports of the kettlebell swing as an important tool for improving and maintaining lower back health. With proper technique maintenance, the kettlebell swing appears to be a safe full-body resistance training exercise, and an ideal exercise for a challenging framework like the Tabata interval. A caveat remains however, wherein the level of acute changes in HR found during both the TRAD (average of 73% of maximum heart rate) and Tabata (average of 81% of maximum heart rate) kettlebell swing protocols approach/fall into the vigorous exercise intensity category (76-<96% of HR_{max}) outlined by the ACSM (10). Due to these findings, it is paramount that careful screening procedures and risk stratification precede *any* exercise program that involves the kettlebell swing (1, 10).

To the authors' knowledge, this is the first study to examine the characteristics of repetitive kettlebell swings with a HIIT protocol. During TAB, the average level of oxygen consumption reached around 70% of the peak VO_2 value (12% greater than the TRAD protocol) measured during aerobic capacity testing. This is similar to the 65.3±9.8% VO_{2max} value reported in a 12-minute max repetition kettlebell protocol in the study by Farrar and colleagues (2), deemed sufficient for increasing aerobic capacity. Hulsey and colleagues (6), comparing kettlebell swings with treadmill running, concurred that similar (35s work, 25s rest) intervals of kettlebell swings for 10 minutes would provide an ample stimulus for aerobic improvement. It is likely that the Tabata protocol would fit the criteria to improve aerobic capacity, with the addition of the kettlebell swing also addressing divergent physiological mechanisms related to anaerobic capacity, and improved strength and power (10). Aside from achieving evidence of the sufficient aerobic contribution to Tabata kettlebell swings, the present finding of increased concentrations of blood lactate in the immediate and one-minute post-exercise window point to the potential for an increased contribution of anaerobic metabolism, in line with other previous reports (12, 13). A five-week training stimulus under HIIT conditions has also demonstrated evidence of an increased maximal lactate accumulation, likely a cumulative effect of anaerobic stimuli during repeated acute HIIT bouts (15).

In this initial investigation, only one Tabata interval (4 minutes) was utilized in each TAB condition, whereas consecutive intervals (10-12 min range) similar to HIIT volumes previously shown to be beneficial (13,15), may have shown improved outcomes. Also, due to initial concerns with the safety of adding external resistance to the Tabata interval, the implements used in the study were relatively light. It is likely that the use of larger kettlebells, for example 16kg for men and 8kg for women (7), would result in even greater cardiovascular and metabolic contributions. Studies designed to determine the appropriate load, frequency, volume, and periodization of Tabata programming using the kettlebell swing would logically progress from these findings. Also, studies designed to characterize potential long-term improvements of this drill outside of aerobic and anaerobic conditioning (e.g. power); and determine how these adaptations may contribute to improved health, as well as sport- and activity-specific performance, are warranted.

The use of the kettlebell swing in a Tabata interval framework may safely and effectively provide multi-faceted exercise adaptations with a relatively short time investment. High-repetition kettlebell swings, regardless of protocol, may elicit a vigorous cardiovascular response; therefore it is advisable to exercise caution with moderate- and high-risk individuals.

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