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METABOLIC AND CARDIOVASCULAR DEMANDS OF A HIGH-INTENSITY INTERVAL EXERCISE BOUT UTILIZING A SUSPENSION DEVICE

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ABSTRACT

Two methods of training, high-intensity interval training (HIIT) and suspension device training, have recently gained popularity in the fitness and health industry. Purported effects of these rapid, efficient workouts (HIIT) and functional training devices include weight loss, cardiovascular improvements, and other health benefits. However, limited or no data currently exists combining these two methods of training. Therefore, the purpose of this study to determine the cardiovascular and metabolic demands of a high-intensity training program performed on a suspension device. Twelve, apparently healthy, men (n=9) and women (n=3), mean age = 24.67 ± 2.90, volunteered to participate in this study. Participants performed a pre-programmed HIIT suspension device program (i.e., TRX® Metabolic Blast) consisting of nine body weight exercises, followed by a 1 minute cardio sprint. Results demonstrated that the exercise bout elicited an average heart rate of 148.0 ± 12.0 beats$\cdot$min^{-1}, or 82.99 ± 4.20% HR_{max}. The bout produced a mean VO_2 of 24.34 ± 3.24 ml$\cdot$kg$^{-1}\cdot$min^{-1}, which was 55.97 ± 5.82% VO_{2max}. Total caloric expenditure for the HIIT program resulted in 96.98 ± 19.49 kcals, or approximately 10.78 ± 2.17 kcals$\cdot$min^{-1}. While average MET levels for the workout were equal to 6.94 ± 0.93. Results of suggest that the exercise bout could be classified as “moderate-to-high intensity” exercise according to the established American College of Sports Medicine guidelines. While, the workout elicited a vigorous intensity heart rate, only a moderate percentage of $VO_{2max}$was obtained. Therefore, cardiovascular adaptations may not be seen in semi- to highly-trained individuals.

Keywords: Suspension Training, HIIT, High-intensity exercise, TRX

INTRODUCTION

High-intensity interval training (HIIT) and suspension devices have been increasing in popularity in the health and fitness industry. Typically consisting of rapid movements, high repetitions, and minimal rest periods, circuit-style weight training programs have often been used as a means of increasing lean tissue (21,30), improving body composition (21,29), and increasing muscular capacity (16,22,29). Although programs and rest times may vary between workouts (10-13,16,20-25,30), the ideology of performing at a high-intensity effort (e.g., ≥ 85% HR_{max}) with minimal or no rest, (e.g., ≤ 30 seconds) is the same.

While typical resistance training programs have shown to not efficiently improve the cardiovascular system (5,11); interval and circuit training programs have shown varying results in aerobic conditioning (5,23,25). HIIT training has also been shown to be a safe form of exercise across multiple populations including sedentary and recreationally trained individuals (20,21,29), older individuals' (24), athletes (25), and even cardiac disease patients (8,16).

Suspension device training, a mimicking style of the gymnastic rings, has gained popularity due to its' creative exercises utilizing an individuals' own bodyweight as resistance. The belief behind this style of performing movements, with hanging straps and handles, is for subjects to increase muscular activity in order to maintain stability and balance. Increases in muscle activity used to stabilize the body during suspension training may increase the intensity of traditional bodyweight exercises (4,19,27,28). In addition, recent research by Janot et al., (14) found that after 7 weeks of suspension device training, participant's significantly improved hip flexor and back extensor endurance, hamstring flexibility, and fall risk balance; which are common improvements associated with traditional resistance training. Dudgeon et al., (9), and Scheett et al., (26), have also examined suspension training circuits and found increased anabolic hormonal responses (i.e., growth hormone and testosterone) and decreased catabolic responses (i.e., cortisol).

However, more research into the acute physiological and cardiovascular demands is needed while using a suspension device, especially when incorporated into a HIIT format. Therefore, the purpose of this investigation was to investigate the metabolic and cardiovascular demands of a high-intensity interval training program utilizing a suspension device in physically active individuals.

METHODS

Participants

Subjects for this investigation were recruited via flyers and word of mouth. Subjects (n = 12) consisted of 9 men and 3 women who volunteered to participate in this study. All descriptive statistics for the subjects are shown in Table 1. Prior to testing, all subjects were informed of the potential discomforts and risk that could occur and were asked to complete a health history questionnaire and informed consent. Only the individuals who were classified as low risk, according to the American College of Sports Medicine were chosen to participate. Individuals who were currently injured, possessed any cardiovascular, metabolic, or any other medical restriction that would prohibit full participation were asked to refrain from the study. All subjects reported as being physically active with at least six months of previous resistance training experience. Five subjects had previous experience using a suspension device; however, none of the participants had performed the investigated workout prior to the study.

Table 1. *Descriptivestatistics of thestudyparticipants*

	Men (n = 9)	Women (n = 3)	All (n = 12)
Age (yr)	25.11 ± 3.22	23.33 ± 1.15	24.67 ± 2.90
Height (cm)	179.10 ± 8.61	173.80 ± 5.50	177.66 ± 8.41
Bodymass (kg)	83.30 ± 9.49	71.00 ± 2.00	78.92 ± 8.50
BodyFat (%)	11.67 ± 5.76	22.78 ± 3.05	13.87 ± 7.31

Protocol

Subjects were asked to report for testing on two separate occasions. During the first laboratory visit, descriptive statistics (i.e., age, height, and weight) were collected for each participant along with a graded exercise test (GXT) to determine maximal aerobic capacity (VO_{2max}). Subjects were asked to refrain from heavy intensity exercise, caffeine, and alcohol 24 hours before testing. Height was measured to nearest 0.1 cm with participants standing,without shoes, against a wall-mounted stadiometer (SECA 220; Seca, Ltd., Hamburg, Germany); while weight was measured with light clothing and without shoes to the nearest 0.1 kg using a digital scale (Tanita BWB-800a; Tanita, Inc., Tokyo, Japan). Body composition was measured using the InBody 720 (InBody 720, Biospace Co., Seoul, Korea). Test-retest procedures were performed on a separate group of active men and women (n = 20), which demonstrated that the InBody 720 device provided good reliability for BF% (ICC = 0.99, SEM = 0.16).

Graded Exercise Testing (VO_{2max})

Criterion VO_{2max} was determined via a portable metabolic analyzer (COSMED® K2b4®; Cosmed, Chicago, IL, USA) andGXT. The test was completed on a Trackmaster treadmill (Full Vision, Inc., Carrollton, TX) to determine VO_{2max}. The Bruce protocol (5) was used for the GXT which involved a series of 3-minute stages with consecutive increases in speed and grade until at least two of the following criteria occurred: a plateau in VO_2 ($\pm$ 2 ml·kg^{-1}·min^{-1}) despite an increase in work rate; respiratory exchange ratio $\geq$ 1.15; heart rate within 10 beats of age predicted maximum (220 – age); or volitional fatigue. Along with VO_{2max}, maximal exercise heart rate (HR_{max}) was determined via a Polar® electronic heart monitor (Polar® Electro Oy, Kemple, Finland).

Exercise Bout

On the second visit, subjects completed a pre-programmed, high-intensity interval training workout (i.e., TRX® Metabolic Blast®) utilizing a suspension device. The TRX® Metabolic Blast® is a bodyweight circuit designed to incorporate both interval training and a suspension device into a quick-paced, anaerobic workout program. Subjects were set up with a portable metabolic analyzer (i.e., COSMED®) and heart rate monitor (i.e., Polar® strap) during the workout to determine average volume of oxygen consumed (VO_2), mean heart rate (HR), total energy expenditure (EE_{total}), and rate of caloric expenditure (kcals·min^{-1}). The workout consisted of nine exercises including the atomic oblique push-up, side plank, sprinter start, chest press, single-leg squat hop, kneeling roll-out, reverse fly, back row, and hamstring curl. All exercises were performed for 30 seconds each, along with a 15 second rest period between exercises. Once all of the exercises were complete, subjects performed a 1 minute cardio sprint on the treadmill at an individual rating of perceived exertion (RPE) of 8-9 out of 10 according to the Borg scale. The total time of the exercise bout was 9 minutes. All participants were instructed and familiarized with proper technique for each movement prior to testing. During the testing, participants were asked to complete as many repetitions as possible of each movement while avoiding any excessive breakdowns in proper form.

Statistical Analysis

Data was analyzed using SPSS/PASW Statistics version 18.0 (Somers, NY). Mean and standard deviations (SD) were calculated for each of the following variables: age (yr), height (cm), weight (kg), heart rate (bpm), VO_2 (ml·kg^{-1}·min^{-1}), and caloric expenditure (kcals·min^{-1}). The mean VO_2 and HR values were also expressed as percentages (%) of VO_{2max} and HR_{max}, respectively.

RESULTS

All subjects who consented to the study completed the entire data collection process. The GXT provided a HR_{max} of 178.33 ± 11.2 bpm, as well as a VO_{2max} of 43.83 ± 6.58 ml·kg^{-1}·min^{-1} for all participants. During the HIIT program, the average HR observed was 148.0± 12.0 beats·min^{-1}, which was approximately 82.99 ± 4.20% of HR_{max}. The mean VO_2 throughout the exercise session was 24.34 ± 3.24 ml·kg^{-1}·min^{-1}, which equated to 55.97 ± 5.82% of the measured VO_{2max}. The mean total EE was 96.98 ± 19.49 kcals, which equated to 10.78 ± 2.17 kcals·min^{-1}. The MET levels obtained during the HIIT workout were 6.94 ± 0.93. All values are listed in Table 2.

DISCUSSION

The purpose of this study was to determine the metabolic and cardiovascular demands during a HIIT program performed with a suspension device. Results of this investigation suggest that the high-intensity suspension exercise bout elicited ahigh average percentage (vigorous intensity) of HR_{max} (i.e., 83%). However, mean VO_2 provided only moderate intensity levels (46-<64 %VO_{2max}) as determined by guidelines set forth by the American College of Sports Medicine (3).

Table 2. *Mean and SD values for physiological and metabolic variables*

	Men (n = 9)	**Women (n = 3)**	**All (n = 12)**
HR_{avg} (bpm)	150.0 ± 13.54	143.54 ± 3.00	148.0 ± 12.0
%HR_{max}	84.09 ± 3.98	79.70 ± 3.44	82.99 ± 4.20
VO_{2avg} (ml·kg^{-1}·min^{-1})	25.10 ± 3.33	22.07 ± 1.81	24.34 ± 3.24
%VO_{2max}	56.14 ± 6.05	55.45 ± 6.30	55.97 ± 5.82
METs	7.16 ± 0.96	6.29 ± 0.53	6.83 ± 0.90
EE_{total} (kcals)	103.76 ± 15.77*	79.20 ± 11.21	96.98 ± 19.49
Kcals·min^{-1}	11.22 ± 1.70	8.56 ± 1.21	10.78 ± 2.17

*Significantly different than women ($p < 0.05$).
HRavg = Average exercise heart rate;
VO2avg = Average exercise aerobic capacity;
METs = Metabolic Equivalents;
EEtotal = Total caloric energy expenditure

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This pattern of an elevated $\%HR_{max}$ and significantly lower $\%VO_{2max}$ was observed in multiple interval based weight training programs (5,7,10,20). Typically, HR and VO_2 share a linear response in more endurance based low-intensity exercise programs. However, during high-intensity anaerobic workouts, studies have shown an initial rapid HR response, but a low-to-moderate $\%VO_{2max}$ intensity (5,7). It has been previously speculated that this phenomenon is caused by a decreased venous return; thereby not allowing an increase in stroke volume as the intensity increases during exercise (1,13,18). While an extended, elevated heart during exercise is a key component for cardiovascular adaptations, the most influential component is an elevated relative $\%VO_{2max}$ (13).

Previous research of HIIT programs has shown cardiovascular improvements in sedentary and unfit individuals (15). However, within aerobically and advanced resistance-trained populations, maximal oxygen consumption (VO_{2max}) during resistance or circuit-training was not sufficient enough to enhance cardiovascular function due to only moderate VO_2 levels during exercise (11,3,17).

A study performed by Monteiro et al., (20), compared a resistance-based circuit and an interval-based workout containing both free-weights and treadmill running. Researchers found the resistance training circuit elicited higher caloric expenditures and VO_2 values for both males and females as compared to the mixed-interval based workout (20). Therefore, the Monteiro et al., (20), study is in agreement with our findings that resistance training circuits may produce an adequate VO_2 to produce small cardiovascular adaptations and improvements. However, the moderate $\%VO_{2max}$ demonstrated during this study may not equal optimal cardiovascular adaptations when compared against traditional training modalities (e.g., running, jogging, cycling, etc.) (12,13,17). While varying physiologic and cardiovascular levels (i.e., moderate $\%VO_{2max}$ and high $\%HR_{max}$) were observed during the program, these metabolic demands showed potential for future research of chronic adaptations while performing HIIT.

Furthermore, the results of the current study demonstrated overall MET levels of 6.83 ± 0.90. According to ACSM guidelines, these levels can be classified as moderate-to-vigorous activity (3) and are comparable to multiple other modalities of exercise. For instance, running (4.5 to 5 mph), bicycling (moderate effort – 12 mph), calisthenics (moderate-to-heavy effort), rowing (moderate effort – 100-150 watts), and circuit training with short-to-minimal rest periods all mimic the suspension training circuit in terms of intensity levels (2). In terms of EE_{total}, results indicated that individuals expended an average of 96.98 ± 19.49 kcals, or 10.78 ± 2.17 $kcals \cdot min^{-1}$. These levels are also comparable to traditional modes of exercise (e.g., moderate-to-high intensity resistance training (3-9 $kcals \cdot min^{-1}$), running (12-22 $kcals \cdot min^{-1}$), moderate intensity cycling (10-15 $kcals \cdot min^{-1}$), and step aerobics (10-15 $kcals \cdot min^{-1}$).

During the exercise bout, participants expended an average of 1.2 $kcal \cdot kg^{-1}$. This figure is in agreement with a previous study examining a short duration, high-intensity resistance bout (22). Researchers analyzed a 4-minute, 2:1 work-to-rest ratio (i.e., 20 seconds on, 10 seconds off) exercise bout utilizing bodyweight movements. Results, similar to this study, indicated an average caloric expenditure of 1.2 $kcal \cdot kg^{-1}$. A study performed by Pichon et al., (23), also concluded that caloric expenditure was increased during circuit training versus traditional weight lifting. Subjects performed the same four exercises, one with a 1:3 work:rest ratio and 70% 1 repetition maximum (RM) load and another version with a 2:1 ratio and 47% 1 RM load. Researchers found a higher kcal·min^{-1}, total energy expenditure, and significantly higher exercising HR during the circuit training bout (i.e., 2:1 ratio and 47% load) (23). The results of these previous and current studies may have implications for those individuals' wanting a time-efficient exercise bout that may also produce small cardiovascular benefits.

This study is not without limitations. While excess post-exercise oxygen consumption (EPOC) was not measured in this study, HIIT training programs have been shown to burn more calories post-exercise bout as compared to traditional resistance training (11,13,17,22). Second, while performing upon a suspension device, the intensity of each exercise can easily be manipulated by relying more or less on the device itself. For instance, during the single-leg squat hops, one participant may rely more heavily upon pulling themselves to a standing position with their arms; whereas another participant may place more load on the working leg to complete the exercise. This may also occur between repetitions of the same individual, as they fatigue they more put more reliance on the device in order to avoid complete exhaustion of the working muscle. As this was not accounted for, the rate of EE total, %VO2, and %HR may have been affected. Another limitation is that the authors are only aware of one research study that measures the chronic adaptations to suspension training (14). However, the study was not a suspension training HIIT program, but a traditional resistance exercise bout. Therefore, future research is warranted to determine if a high-intensity bout with a suspension device is adequate to produce similar or significantly different results versus traditional weight lifting, aerobic conditioning, or high intensity training.

PRACTICAL APPLICATIONS

HIIT programs combined with suspension devices may provide an adequate stimulus in terms of aerobic and anaerobic training capabilities. While %HR_{max} has been established as vigorous intensity in the current study, %VO_{2max} values were deemed moderate. This information is useful for those individuals' looking to find alternative training methods, while still being able to provide an adequate aerobic and anaerobic stimulus. If the goal of the individual is solely aerobic conditioning, then traditional methods (e.g., running, cycling, swimming, etc.) may be more appropriate. In terms of weight loss and management, this time-efficient program may provide a way for participants to expend a significant amount of calories through the utilization of an individuals' own bodyweight as resistance. Although, future research is warranted to determine if chronic usage of HIIT workouts with a suspension device can provide a suitable alternative to traditional free-weight training.

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