Nuñez et al. (2017) *Int J Res Ex Phys*. 12(2):9-21.

Sponsored by:
Exercise and Sport Science Program
Western State Colorado University

International Journal of Research in Exercise Physiology

Original Research Article

Designing the Optimal Suspension Training Circuit

Tony P. Nuñez[1], Nicholas M. Beltz[1 2], Trisha A. Vandusseldorp[3], Christine M. Mermier[1], Len Kravitz[1]
[1]University of New Mexico, Albuquerque, New Mexico, USA
[2]University of Wisconsin-Eau Claire, Eau Claire, Wisconsin, USA
[3]Kennesaw State University, Kennesaw, Georgia, USA

Abstract

Introduction: Benefits of circuit training have been researched for many years. However, there is no peer-reviewed research regarding energy expenditure when integrating a Suspension Training® (ST) device into a circuit protocol. The primary purpose of this study was to quantify and compare the acute metabolic responses of two commonly utilized ST work protocols, and to determine if there is a difference in these protocols between men and women. Methods: Two work-to-rest ratios [long work (LW) 45:15-sec, short work (SW) 30:15-sec] were employed for a circuit-style ST protocol in trained males (n =12) and females (n = 12), ages 19-28 yrs. Energy expenditure (EE) was determined via indirect calorimetry. In order to match total work time (12 min of total exercise), the LW protocol was performed twice (18 min total workout time) and SW protocol was performed three times (16 min total workout time). Variables analyzed were EE, O_2 consumption (VO_2), heart rate (HR), total repetitions (TR), and rating of perceived exertion (RPE). Protocol comparisons were made using ANOVA with repeated measures ($p \leq 0.05$) for all variables. Results: Total EE was greater in the SW compared to the LW protocol (138 ±31 kcal vs. 122 ±31 kcal, $p < 0.05$), as was TR (416 ±68 reps vs. 383 ±85 reps, $p < 0.05$), respectively. Percent-VO_{2max} for the LW and SW protocols were 45% and 50%, respectively. There was no significant difference between average-EE between the LW and SW protocols. Females had a significantly higher HR response for both protocols compared to males (LW: female = 174 ±6 bpm; male = 158 ±13 bpm; SW: female = 171 ±10 bpm; male = 156 ±14 bpm). Conclusion: Based on $\%VO_{2max}$, both the SW and LW protocols met ACSM adult guidelines for improvement of aerobic capacity in men and women and elicited high EE given the short exercise time. Women had a higher percent-HRmax response compared to men, while men had a higher percent-VO_2max response compared to women.

Key Words: Interval Training, Resistance Exercise, Aerobic Exercise, Metabolic Cost

Introduction

Incorporation of various resistance training modalities has continuously gained popularity in the last 15 to 20 yrs. Resistance training is utilized to elicit improvements in strength, power and endurance for athletes and the general population[1]. Over the past 20 years, exercise selection has expanded from the use of traditional barbells and dumbbells to include a variety of devices, such as kettlebells, battling (heavy) ropes, bands, chains, tires, sledge hammers, sleds, various strongman implements (i.e., log bars, super yokes, farmer's walk bars, and stones) and body weight suspension devices[1,2]. Although many of these specialized pieces of equipment have been around for many years, not until recently have they been commercially available and implemented in a wide spectrum of fitness settings.

Body weight suspension exercise is an increasingly popular resistance training modality implemented in various populations from those seeking general health and fitness to elite tactical and combat athletes, and even in physical therapy clinics. Furthermore, using body weight Suspension Training® (ST) has been shown to promote positive changes in strength, power and jumping ability[3-5] and has been compared to other traditional resistance exercises[6-9]. Suspension trainer devices are used to accommodate multiple types of resistance training design philosophies, such as pulling, pushing, instability and unilateral training. During a typical ST session, the exercises are performed with the subject holding or hanging from the ST straps with the upper or lower body extremities and the opposite end of body anchored using contact with a stable surface (i.e., the ground). For instance, a ST device push-up involves the suspension of both feet in the straps while the hands are in direct contact with the ground. Determining whether ST performed in a circuit format can elicit aerobic responses recommended by the ACSM guidelines[10] for improvements in cardiorespiratory fitness may be beneficial for exercise programming. Previous research has determined that ST exercise is a suitable option for improvements in strength[4-5]; thus, if an aerobic response is evident it may be an appropriate program for improvements in all-around health.

The primary purpose of this study was to quantify and compare the acute metabolic responses of two commonly utilized ST work protocols (long work (LW): 45 sec work, 15 sec rest; short work (SW): 30 sec work, 15 sec rest), and to determine if there is a difference in these protocols between men and women. It was hypothesized that the ST exercise protocol using a longer work interval (45 sec) would elicit the greatest acute metabolic responses, and the responses would be higher in males than females.

Methods

Participants

Twenty-four healthy, resistance-trained college-aged men (*n* = 12) and women (*n*= 12) between the ages of 19 and 28 years participated in this study (Table 1). Resistance-trained was defined as participating in a minimum of 30-45 min of resistance training at least three times per week for at least the past 6 months before enrolment. All subjects were considered low risk and reported no limiting musculoskeletal injuries in accordance with the ACSM guidelines[10] and the Physical Activity Readiness Questionnaire. Additionally, no subject reported taking any medications or supplements known to affect exercise performance. Subjects were required to have previous experience (minimum of one exercise session) with a ST device. Additionally, each subject underwent a familiarization session before testing on the device. Familiarization focused on the subjects' ability to perform each ST exercise with proper form and technique. Upon arrival for the initial testing session, each subject's height was measured using a wall-mounted stadiometer (Holtain Limited, Crymych Dyfed, Great Britain). Body mass was measured using an electronic scale (Itin Scale Company, Brooklyn, NY USA). Percent body fat was estimated by a 3-site skinfold test[11-12] using a Lange skinfold calliper (Beta Technology, Santa Cruz, CA USA). The sites measured were the pectoral, abdominal, and anterior thigh skinfolds for men, and the triceps, suprailiac and anterior thigh skinfolds for women. Body density was calculated using the sum of the 3-sites, and converted to percent body fat[13]. To ensure reliability, the same experienced researcher performed all skinfold assessments. This study was approved by the University Institutional Review Board, and each subject signed an informed consent document before participation. No subject had any physiological or orthopaedic limitations that could have affected exercise performance as determined by completion of a physical activity readiness questionnaire.

Maximal Aerobic Capacity (VO_2max) Testing

Following anthropometric measurement during the initial session, each subject performed a maximal aerobic capacity (VO_2max) test. Subjects were asked to refrain from any strenuous exercise for at least 24 hours prior to the maximal testing session. VO_2max was assessed by a progressive multistage ramp protocol on a treadmill using a metabolic gas analyzer (Parvo Medics TrueOne, Sandy, UT, USA). The speed (mph) for the initial stage of the test was individualized for each subject. The testing protocol consisted of 1-min stages with increases of either 0.5 mph in speed or 1% grade in each subsequent stage. All subjects were verbally encouraged to continue exercise until volitional exhaustion. Breath-by-breath data were obtained, and VO_2max was determined by the highest value achieved using a 15-sec

Table 1. Subject descriptive characteristics.

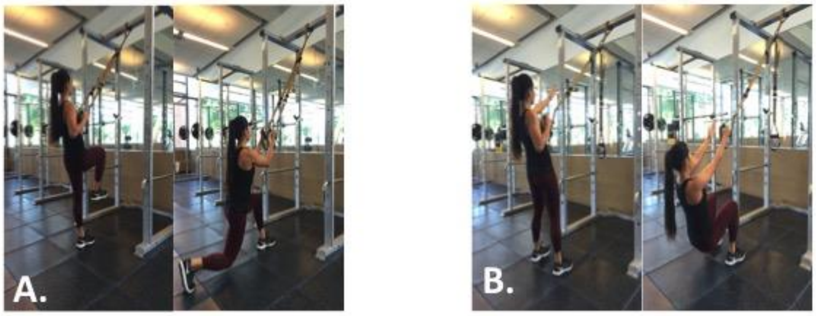
	Males (n = 12)	**Females (n = 12)**
Age (y)	23.3 ±2.8	20.3 ±1.3*
Height (cm)	172.2 ±6.7	162.5 ±4.3*
Weight (kg)	75.0 ±8.8	57.8 ±7.2*
Body mass index ($kg \cdot m^2$)	25.3 ±2.3	21.9 ±2.5*
Body fat (%)	8.3 ±3.7	18.7 ±3.7*
VO_2max ($mL \cdot kg^{-1} \cdot min^{-1}$)	51.1 ±7.3	41.8 ±4.7*

* Values for females are significantly different from males, $p < 0.05$.

average. Maximal oxygen consumption was confirmed when an individual subject attained the three following criteria: heart rate within 10 beats of age-predicted max, respiratory exchange ratio equal to or greater than 1.15 and rating of perceived exertion greater than 17. The same metabolic cart was used for every test and was calibrated according to manufacturer guidelines before each trial. Following the VO_2max test, subjects were familiarized with the ST exercise circuit and performed each exercise for as many repetitions necessary to become comfortable with performing the movement with proper execution.

Suspension Training Protocols

Subjects reported to the Exercise Physiology Lab for the first exercise session a minimum of 48 hours following the initial VO_2max testing session. Exercise testing program sequence was randomized such that each subject blindly selected a card containing either the SW or LW protocol. Subjects were given at least 24 hours between exercise sessions. Upon arrival, each subject was weighed, re-familiarized with the ST circuit, and performed a standardized 5-min dynamic warm-up. The warm-up consisted of timed dynamic movements, including dynamic stretching, lunges and body weight upper body exercises. Subsequently, subjects were fitted with a Hans-Rudolph two-way valve mouthpiece (Hans-Rudolph Inc., Kansas City, MO, USA) and Polar heart rate monitor (Polar Electro Inc., Woodbury, NY, USA). Breath-by-breath oxygen uptake (VO_2) was measured throughout each protocol. The metabolic cart and tube were maneuvered during the protocols in a manner that allowed for exercises to be completed properly. Heart rate data was also collected and averaged breath-by-breath throughout the ST protocols. Rating of perceived exertion (RPE) was obtained at the end of each exercise trial using a 6-20 scale[14].

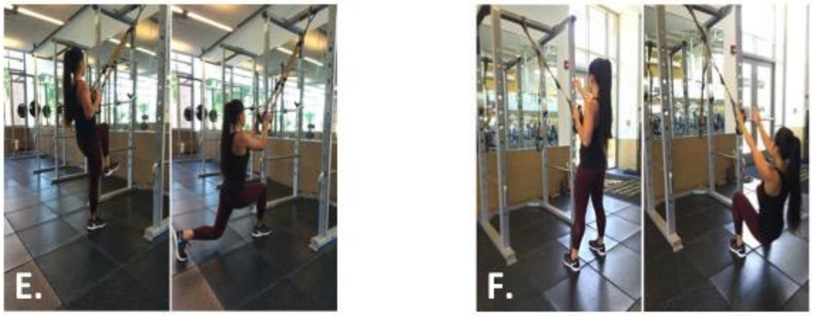


A. Drop Back Lunge to Knee Drive (right side)

B. Single-Arm Squat to Row (right side)

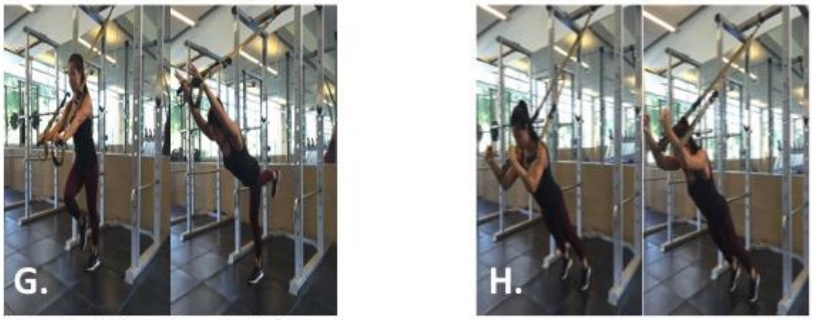
C. Single-Leg Reach (right side)

D. TRX Chest Press



E. Drop Back Lunge to Knee Drive (left side)

F. Single-Arm Squat to Row (left side)



G. Single-Leg Reach (left side)

H. TRX Plank Press

Figure 1. Suspension Training Circuit Exercises.

Subjects either performed the SW or LW protocol, where rest periods remained constant and work periods were manipulated for either 30 sec or 45 sec. Eight exercises were selected for the ST protocol in a full body workout format. The following exercises were selected in the specified order: (A) Drop back Lunge to Knee Drive (right side), (B) Single-Arm Squat to Row (right side), (C) Single-Leg Reach (right side), (D) TRX Chest Press, (E) Drop back Lunge to Knee Drive (left side), (F) Single-Arm Squat to Row (left side), (G) Single-Leg Reach (left side), (H) TRX Plank Press. See **Figure 1** for illustration of the exercises. Subjects were asked to perform as many repetitions as possible during the work periods and had the ability to manipulate intensity based on vector angle (angle to the ground). Prior to each ST protocol, subjects were reminded that more horizontal angles to the ground created more difficulty and vice versa for more vertical angles. Number of repetitions was not controlled in order to allow for a natural fatiguing effect produced by the work durations. Subjects were instructed to perform movements at an angle that would allow for proper execution of the exercise for the full duration of the work interval. A research team member kept time with an interval timer application (Deltaworks Limited, London, UK) and counted repetitions (Hand Tally Counter, ATAFA, Cambridge, MA USA) during each protocol. Auditory signals with the interval timer application were provided to begin and terminate exercise. The ST device used was a TRX Suspension Trainer (Fitness Anywhere LLC, CA, USA) and was anchored according to company guidelines. For exercises 1, 2, 5, and 6, a fully shortened (straps at shortest length) TRX was used, and for exercises 3, 4, 7, and 8, straps were positioned so the handles were at knee height for the subject. Following each protocol, the Hans-Rudolph valve was removed and subjects walked on a treadmill for a 3-minute cool down.

Metabolic and Cardiorespiratory Measurements

Heart rate and VO_2 data were measured continuously during each exercise session. Individual breath-by-breath data points for all metabolic variables were averaged for the entire protocol. Gross energy expenditure (EE) in kilocalories for each protocol was measured using the metabolic software system. Average energy expenditure (AEE) in kilocalories per minute was calculated by dividing the EE by the protocol duration (SW: 18 min, LW: 16 min). Percent-HRmax (%HRmax) and percent-VO_2max (%VO_2max) were determined by dividing the average HR and VO_2 for the protocol by the measured HRmax and VO_2max from the maximal oxygen consumption test for each subject.

Statistical analyses

Descriptive statistics (mean ± *SD*) were calculated for all dependent variables. A within and between group analysis of variance (ANOVA) was used to analyse metabolic, RPE, total repetitions and HR data. Tukey's post hoc tests were used to determine differences when significant main effects were found. For all statistical tests, a probability level of $p \leq 0.05$ was set *a priori* to assess statistical significance.

Results

VO₂

There was no significant difference between the average relative VO_2 for the LW (22.4 ±3.2 ml/kg/min) and the SW (22.8 ±2.9 ml/kg/min) protocols. Also, no significant difference was found between the average $\%VO_{2max}$ for the LW (48.6 ±4.9%) and SW (49.6 ±5.8%) protocols. VO_2 data are presented in **Figure 2** and **Figure 3**. **Figure 2** depicts the average relative VO_2 response for male and female subjects during the LW protocol. Average relative VO_2 for the protocol was significantly greater ($F(1,22)=6.146$, $p<0.05$) in the male group (23.9 ± 2.7 ml/kg/min) compared to the female group (20.9 ± 3.0 ml/kg/min). In the LW protocol a greater $\%VO_{2max}$ was elicited in the females (50.0% ±4.7%) compared to the males (47.2% ±4.8%), but no significant difference was found between sexes.

Figure 3 depicts the average VO_2 response for male and female subjects during the SW protocol. Similar to the findings of the LW protocol, average relative VO_2 was significantly ($F(1,22)=6.146$, $p<0.05$) greater in the males (23.9 ± 2.7 ml/kg/min) compared to the females (21.6 ±2.6 ml/kg/min). However, there was no sex by protocol interaction. The males had the same relative average VO_2 for both LW and SW protocols. Females had a 5% higher ($p>0.05$) $\%VO_{2max}$ (52.0% ±5.3) compared to the males (47.3% ±5.6) during the SW protocol. Females also had higher ($p>0.05$) $\%VO_{2max}$ values during the SW compared to the LW protocol.

Energy expenditure

Energy expenditure was significantly greater ($F(1,22)=62.11$, $p<0.05$) during the SW (TEE = 138 ±31 kcal) compared to the LW (TEE = 122 ±31 kcal) protocol. Between-subjects effect revealed that the males had a significantly ($F(1,22)=41.11$, $p<0.05$) higher total EE compared to females. There was no significant sex by protocol interaction.

Average EE showed no significant difference between the LW (AveEE = 7.6 ±1.7 kcal/min) and SW (AveEE = 7.6 ±1.9 kcal/min) protocols. For both protocols there was a significant within-subjects effect ($F(1,22)=41.22$, $p<0.05$) for AveEE between males (LW = 9.0 ±1.4 kcal/min; SW = 9.1 ±1.5 kcal/min) and females (LW = 6.3 ±0.6 kcal/min; SW = 6.1 ±0.6 kcal/min).

Heart rate

A higher HR response was elicited during the LW (HR = 166 ±13 bpm) compared to the SW (HR = 163 ±13 bpm) protocol, but there was no significant ($p>0.05$) difference for the sex by protocol interaction for HR

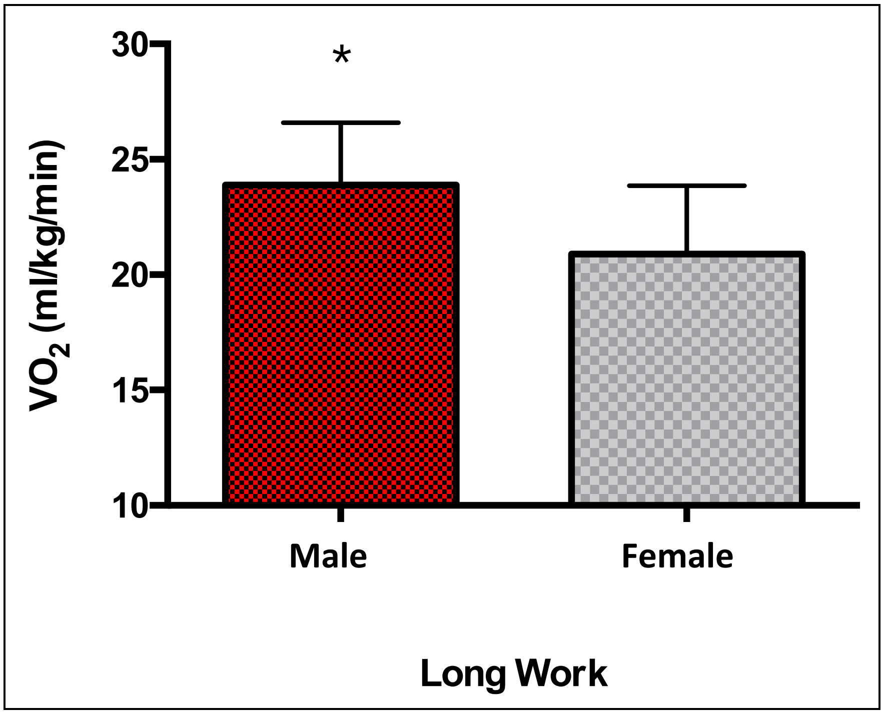


Figure 2. Average VO_2 (ml/kg/min) response to Long Work protocol in males and females. Males demonstrated a significantly higher average VO_2 compared to females during the LW protocol ($p<0.05$). All data are presented in mean ±*sd*.

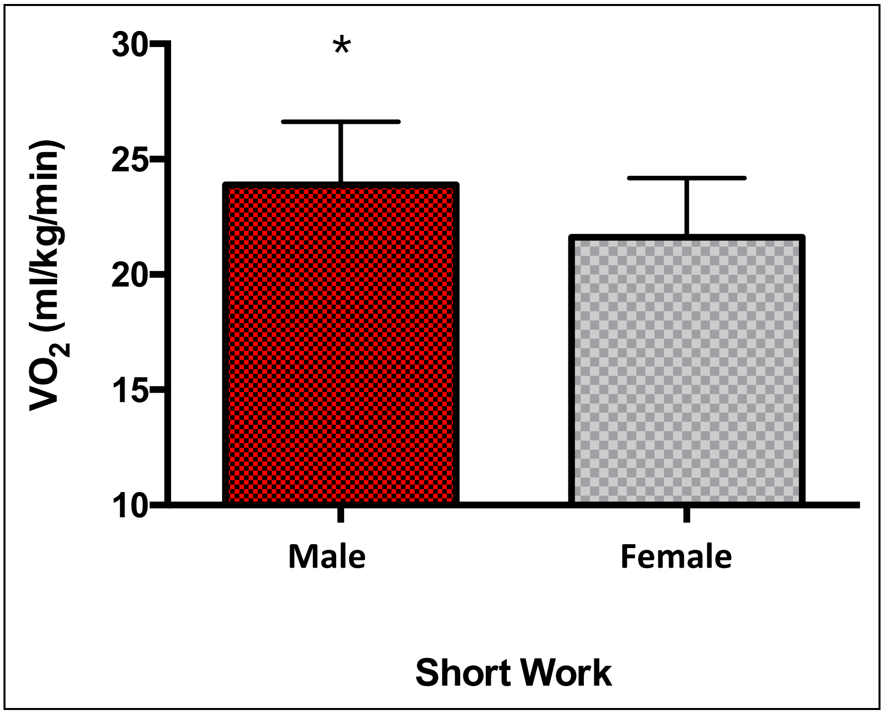


Figure 3. Average VO_2 (ml/kg/min) response to the short work (SW) protocol. Males demonstrated a significantly higher average VO_2 compared to females during the SW protocol ($p<0.05$). All data are presented in mean ±*sd*.

Figure 4. Average heart rate (HR) response to the Long Work protocol between males and females. Females elicited a significantly higher HR response compared to males during the LW protocol (*p*<0.05). All data are presented in mean ±*sd*.

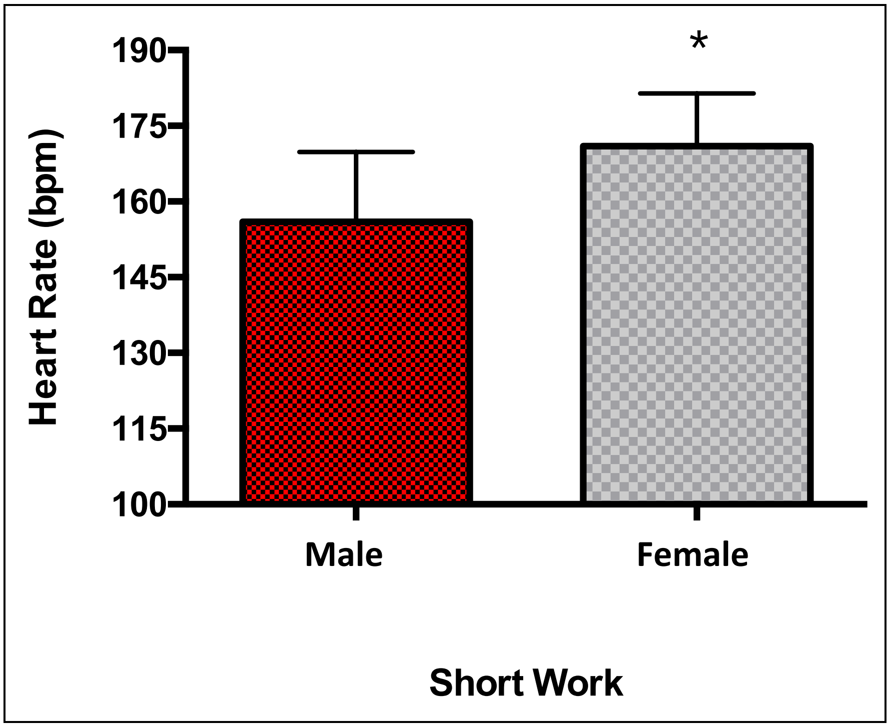


Figure 5. Average heart rate (HR) response to the Short Work (SW) protocol between males and females. Females elicited a significantly higher HR response compared to males during the SW protocol (*p*<0.05). All data are presented in mean ±*sd*.

response. Females had a significantly higher HR response (*F*(1,22)=11.99, $p<0.05$) compared to males (**Figure 4 and Figure 5**) for both protocols (LW: male = 158 ±13 bpm; female = 174 ±6 bpm; SW: male = 156 ±14 bpm; female = 171 ±10 bpm).

No significant difference was found for %HRmax between the LW and SW protocols. However, $\%HR_{max}$ was significantly greater (*F*(1,22)=18.72, $p<0.05$) in females compared to males (LW: male = 80.4 ±5.8%; female = 90.4 ±4.8%; SW: male = 79.6 ±5.8%; female = 88.7 ±6.3%).

Total repetitions and RPE

Total repetitions was significantly greater (*F*(1,22)=10.84, $p<0.05$) during the SW (TR = 416 ±68 reps) compared to the LW (TR = 383 ±85 reps) protocol. Males completed a greater number of repetitions (SW: 440 ±73 reps; LW: 408 ±98 reps) compared to females (SW: 393 ±56 reps; LW: 357 ±65 reps), but no significant difference was found between sexes.

Rating of perceived exertion was significantly higher (*F*(1,22)=14.00, $p<0.05$) during the LW (17 ± 2) compared to the SW protocol (15 ± 2). There was no difference between males and females for RPE.

Discussion

This is the first acute study to compare different work intervals (45 sec vs. 30 sec) in commonly used ST exercise protocols. The TEE data show that the SW protocol elicited a higher energy cost compared to the LW protocol. The discrepancy in total workout time between the SW (18 min) and LW (16 min) protocol likely contributed to the significantly greater TEE. With AveEE, there was no difference between the LW (7.6 kcal/min) compared to the SW (7.6 kcal/min) protocol. These AveEE values are higher than those observed (4.04 and 6.21 kcal/min for women and men, respectively) in the Beckham and Earnest[15] study, which examined the EE of circuit weight training (CWT) with free weights at low and moderate intensities. Subjects in the current study worked at higher intensities compared to those in the Beckham and Earnest study, which may explain the difference in AveEE. Differences in intensities relating to VO_2 and HR for the current study will be discussed in detail in the latter part of this manuscript. In the current study, males (9.1 kcal/min) also elicited higher AveEE compared to females (6.2 kcal/min) for both LW and SW protocols. This difference in AveEE is most likely due to the fact that the male subjects had a larger body mass (75.0 ±8.8 kg) as compared to females (57.8 ±7.2 kg). These results are similar to those exhibited in other CWT studies examining males and females[15-16].

There was no difference between the LW and SW protocol for relative VO_2 (ml/kg/min) in the current study. Because this is the first report to analyze relative VO_2 changes during different work intervals with ST exercise, there is no comparison to be made with previous investigations. Males elicited a higher relative VO_2 compared to females for both the LW and SW protocols. This is likely due to the fact that the male subjects had higher VO_{2max} (51.1 ml/kg/min) values compared to females (41.8 ml/kg/min), as well as larger body mass. The larger body mass elicits a higher absolute intensity due to the nature of ST exercise, which requires subjects to move their own body weight. This finding is also consistent with other CWT research that has compared males and females[15-16]. However, the current study elicited higher relative VO_2 (ml/kg/min) values for males and females compared to both the Beckham and Earnest[15] and Wilmore et al.[16] studies.

Percent-VO_{2max} did not differ between the LW (48.6%) and SW (49.7%) protocols in the current study. Similar to relative VO_2, there is no previous research on the effect of work interval length on %VO_{2max} during CWT. While not statistically significant, females (51.0%) demonstrated higher %VO_{2max} values compared to males (47.3%) for both work intervals. This finding is consistent with that of Beckham and Earnest[15], who also demonstrated higher %VO_{2max} values in females compared to males during light and moderate resistance CWT. Examining only the moderate resistance condition of the Beckham and Earnest[15] study, the current study elicited much higher %VO_{2max} values for both males (47.3% vs. 29.4%) and females (51.0% vs. 31.9%). Percent-VO_{2max} values in the current study were also higher than those in the Wilmore et al.[16] study for both males (47.3% vs. 41.1%) and females (51.0% vs. 46.8%). Furthermore, %VO_{2max} from both the LW and SW protocols met the guidelines for moderate (i.e., 40−<60% VO_2R) intensity according to the American College of Sports Medicine (ACSM) recommendations for improvement of cardiorespiratory endurance. However, it should be noted that the current total exercise durations (16 and 18 min) did not meet ACSM recommendations for cardiorespiratory endurance exercise (≥30 min/day) performed at moderate intensities.

There was no difference in HR and %HR_{max} between the LW and SW protocols in the current study. Females had a significantly higher HR and %HR_{max} (172.2 bpm and 89.6%) as compared to males (157 bpm and 80.0%) during the LW and SW protocols. This was consistent with the findings of Wilmore et al. [16] that demonstrated higher HR and %HRmax in females (162.9 bpm and 87.6%) compared to males (145.3 bpm and 78.3%) following a CWT exercise protocol. However, HR was lower in the females (119.2 bpm and 61.5%) compared to the males (129.5 bpm and 65.4%) in the Beckham and Earnest[15] study. The current study demonstrated higher HR values overall compared to both the Wilmore et al. and Beckham and Earnest study, and is likely attributed to the methodology of the exercise protocol. Unlike the Wilmore et al. and Beckham and Earnest studies, the subjects in the current study did not have predetermined load intensities. Currently, determination of load with the use ST devices is not possible. Subjects exercised at their maximal effort for both protocols. This may have allowed subjects in the current study to exercise at higher load intensities during the work intervals.

The number of repetitions performed during the SW (416.3 reps) was greater than during the LW (382.7 reps) protocol. Despite both the LW and SW protocols having identical total work time (720 sec), subjects performed more repetitions in the SW compared to the LW protocol. It could be suggested that the longer work protocol (45 sec) lead to a greater level of acidosis hindering the ability to perform a similar number of repetitions compared to the shorter work protocol (30 sec). Gollnick and colleagues[17] determined that with higher exercise intensities a reduction in pH (i.e., acidosis) is an observed and essential process of the intense muscular activity.

Some limitations for the current study include controlling for movement velocity and vector angles during the ST exercise. Subjects performed the exercises at a self-selected angle and at his or her own pace, which influenced the overall load of the workout. The number of repetitions performed was purposely not controlled, as subjects selected their own pace during the work periods, which would also have an effect on the overall load of the workout.

Conclusions

In summary, both males and females elicited suitable %VO_{2max} and %HR_{max} to provide a cardiovascular training response while performing a ST exercise circuit. A longer work interval did not lead to an increase in average EE (kcal/min) during the ST exercise protocol. Differences in total EE can be attributed to the discrepancy in total exercise time. Energy expenditure was higher in males compared to females; however, females demonstrated higher %VO_{2max} and %HR_{max} compared to males in both protocols. According to the results of our study, ST performed in a circuit format can be beneficial for cardiorespiratory endurance and previous studies have shown ST to lead to improvements in muscular fitness[4-5]. This can prove ST to be a beneficial exercise format for individuals interested in improving all-around fitness with limited equipment and in a time efficient manner. Future directions of research should determine the chronic training effects of the ST exercise training protocols tested in the current study.

ACKNOWLEDGEMENTS

This study was funded by a grant from Fitness Anywhere LLC.

ADDRESS FOR CORRESPONDENCE

Nuñez, TP, MS, Health, Exercise and Sports Sciences, University of New Mexico, Albuquerque, NM 87131. (805) 844-8699; tnunez12@gmail.com.

References

1. Ratamess NA (2013). Advanced Program Options. In B. Bushman (Ed.) ACSM's Resources for the Personal Trainer (pp. 478-503). Baltimore, MD. Lippincott Williams & Wilkins-Wohlers-Kluwer.
2. Ratamess NA, Faigenbaum AD, Mangine GT, Hoffman JR, Kang J. (2007). Acute muscular strength assessment using free weight bars of different thickness. J Strength and Cond Res, 21, 240-244.
3. East WB (2013). A Historical Review and Analysis of Army Physical Readiness Training and Assessment. DTIC Document.
4. Janot J, Heltne T, Welles C, Riedl J, Anderson H, Howard A, Myhre SL. (2013). Effects of TRX versus traditional resistance training programs on measures of muscular performance in adults. J Fit Res, 2, 23-38.
5. Maté-Muñoz J, Antón Monroy AJ, Jiménez PJ, Garnacho-Castaño MV. (2014). Effects of Instability Versus Traditional Resistance Training on Strength, Power and Velocity in Untrained Men. J Sports Sci Med, 13, 460-468.
6. Beach TA, Howarth SJ, Callaghan JP. (2008). Muscular contribution to low-back loading and stiffness during standard and suspended push-ups. Hum Mov Sci, 27, 457-472.
7. Fenwick CM, Brown SH, McGill SM. (2009). Comparison of different rowing exercises: trunk muscle activation and lumbar spine motion, load, and stiffness. J Strength and Cond Res, 23, 350-358.
8. McGill SM, Cannon J, Andersen JT. (2014). Muscle activity and spine load during pulling exercises: influence of stable and labile contact surfaces and technique coaching. J Electromyogr Kinesiol, 24, 652-665.
9. Snarr RL, Esco MR. (2014). Electromyographical comparison of plank variations performed with and without instability devices. J Strength and Cond Res, 28, 3298-3305.
10. Pescatello LS. (2014). ACSM's guidelines for exercise testing and prescription. Baltimore, MD: Lippincott Williams & Wilkins.
11. Jackson AS, Pollock ML, Ward A. (1980). Generalized equations for predicting body density of women. Med Sci Sports Exerc, 12, 175-182.
12. Jackson AS, Pollock ML (1978). Generalized equations for predicting body density of men. Br J Nutr, 40, 497-504.
13. Siri WE. (1956). The gross composition of the body. Adv Biol Med Phys, 4, 239-80.
14. Borg GA. (1982). Psychophysical bases of perceived exertion. Med Sci Sports Exerc, 14, 377-81.
15. Beckham SG, Earnest CP. (2000). Metabolic cost of free weight circuit weight training. J Sports Med Phys Fitness, 40, 118-125.
16. Wilmore JH, Parr RB, Ward P, Vodak PA, Barstow PJ, Pipes TV, Grimditch G, Leslie P. (1978). Energy cost of circuit weight training. Med Sci Sports Exerc, 10, 75-78.
17. Gollnick PD, Bayly WM, Hodgson, DR. (1986). Exercise intensity, training, diet, and lactate concentration in muscle and blood. Med Sci Sports Exerc, 18, 334-340