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Graduate Studies

# RELATIVE EXERCISE INTENSITY AND ENERGY EXPENDITURE OF BATTLE ROPE EXERCISE

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ABSTRACT

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**Purpose:** The purpose of this study was to determine the relative exercise intensity and energy expenditure of a BR interval exercise session in healthy, active individuals. **Methods:** Fourteen healthy, active male (age 19.6 ± 1.86) participants performed a graded exercise test on the treadmill. Each participant then performed a 14-minute BR workout where each exercise was performed for 15 seconds with a 45 second rest period between exercises. HR, $VO_2$, and RPE were monitored throughout the BR workout. **Results:** The average HR response was 148 ± 14.9 bpm which corresponded to 79 ± 8.4% of HRmax. The average $VO_2$ response was 26.9 ± 5.27 ml/kg/min which corresponded to 51 ± 9.5% of $VO_2$max. The average RPE response was 14.2 ± 1.88. However, RPE rose steadily throughout the workout reaching a peak of 16.3 ± 2.01. The average energy expenditure was 140.9 ± 24.62 total kcals (10.1 ± 1.53 kcals/min). **Conclusion:** A BR interval exercise session would be classified as a vigorous intensity exercise which meets ACSM guidelines for improving cardiorespiratory endurance.

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## INTRODUCTION

According to a survey of the top 20 worldwide fitness trends for 2018, high intensity interval training (HIIT) was number one on the list (Thompson, 2017). High intensity interval training is characterized by bursts of all out exercise followed by complete rest or light-moderate intensity periods (Gibala & Shulgan, 2017). Gibala and Shulgan (2017) state that HIIT provides a very effective workout which can be completed in less time than moderate intensity endurance training. Additionally, HIIT has been shown to improve aerobic fitness and other health benefits to a greater extent than continuous training.

Battle rope (BR) training has become increasingly popular in recent years and is typically performed using HIIT. Battle ropes come in various dimensions, but are generally 30-50 feet long and 1.5 to 2 inches in diameter. Battle ropes are anchored at a secured point (e.g. kettle bell, fence post, tree), and through multiple types of movement patterns, waves are created (Stanforth, Brumitt, Ratamess, Atkins, & Keteyian, 2015). The exercise intensity of BR training depends on a number of factors, including the size, diameter, and length of the rope and the speed and amplitude of the wave motion (Stanforth et al., 2015).

Over the years a limited number of studies have evaluated the responses to BR training. A study by Fountaine and Schmidt (2015) investigated the physiological response to a single session of BR training. One BR exercise was completed for 15

seconds followed by 45 seconds of rest. This sequence was repeated for a total of 10 repetitions. It was found that subjects were exercising at 86% of maximal heart rate (HRmax), which falls into the range recommended by American College of Sports Medicine (ACSM) for improving cardiorespiratory (CR) endurance.

A study by Brewer, Kovacs, Hogan, Felder, and Mitchell (2018) compared the oxygen consumption ($VO_2$), heart rate (HR), and rating of perceived exertion (RPE) responses during a BR workout in a seated versus a standing position. The subjects in the seated BR workout group performed a bicycle $VO_2$max test while the subjects in the standing BR workout group performed a treadmill $VO_2$max test. Both BR workouts consisted 10 sets of double arm waves with each set consisting of 15 seconds of work follow by 45 seconds of rest. It was concluded that BR performed while sitting or standing are very similar in metabolic responses and can improve CR endurance.

Ratamess et al. (2015a) compared a BR circuit to other types of resistance training exercises. Thirteen resistance exercises were performed on separate days: seven free weight, five body weight, and a BR circuit consisting of three exercises. For the free weight protocol, subjects performed 3 sets of 10 repetitions with 75% of their 1 repetition maximum. Multiple sets and repetitions were used for the body weight exercises. For the push-up and push-up on a BOSU ball protocols, subjects performed 3 sets of 20 repetitions. For the burpee and push-up with lateral crawl protocols, subjects also performed 3 sets of 10 repetitions. For the plank and BR circuit protocols, subjects performed 3 sets of 30-second bouts. A standard 2-minute rest interval was used between all sets for each exercise. The BR protocol yielded the greatest $VO_2$ ($38.6 \pm 4.7$

ml/kg/min), HR (153.5 ± 13.9 beats/min), and energy expenditure (10.3 ± 1.4 kcals/min) responses.

A separate study by Ratamess et al. (2015b) examined the effects of varied rest intervals on the responses to BR training. Two exercise sessions were performed on different days, one with a 1-minute rest interval and one with a 2-minute rest interval. Blood lactate was taken at rest and after each BR series. Both intervals resulted in significantly higher blood lactate than at baseline, but the 1-minute rest interval resulted in the highest blood lactate measurement. Oxygen consumption was also measured during both exercise sessions. Values were significantly higher for the exercise session that incorporated the 1-minute rest interval. It was concluded that a BR interval exercise with shorter rest intervals will have a greater effect on CR responses compared to a protocol with longer rest intervals.

The purpose of this study was to determine relative exercise intensity and energy expenditure (EE) during a BR interval exercise session in healthy, active individuals. According to the guidelines provided by ACSM (2018), exercise intensity needs to be between 46-90% of $VO_2$max and 64-95% of HRmax in order to improve CR fitness. For EE, it is recommended that individuals expend 1,200-2,000 kcal per week (240-400 kcal per exercise session) in order to have a positive effect on body composition (Donnelly et al., 2009).

## METHODS

### Subjects

Fourteen male subjects between the ages of 18-23 years of age were recruited from the La Crosse, WI area. Subjects were considered apparently healthy and active (exercising at least 3 times a week for the past 6 months). All subjects had some experience with BR exercises prior to starting the protocol. Each subject completed a PAR-Q to screen for cardiovascular and orthopedic contraindications to exercise and eligible subjects were provided written informed consent prior to participating in the study. The study was reviewed and approved by the University of Wisconsin – La Crosse Institutional Review Board for the Protection of Human Subjects.

### Procedures

All subjects completed a maximal exercise test on the treadmill and a BR workout. The maximal exercise test on the treadmill was used to determine HRmax and $VO_2$max. Subjects were asked to walk or run on a motorized treadmill at a self-selected pace. The test started at a 0% grade and increase by 2.5% every 2 minutes until volitional exhaustion. Throughout the test, HR was recorded each minute using a Polar HR monitor (Polar Electro, Kempele, Finland), $VO_2$ was measured using an Oxycon Mobile portable metabolic system (CareFusion, Yorbra Linda, CA), and RPE was recorded at the end of each 2-minute stage and at maximal exertion using the 6-20 Borg scale (Borg, 1982). Prior to each test, the metabolic system was calibrated with gases of known concentrations (16.02% $O_2$, 4.00% $CO_2$) and with room air (20.93% $O_2$, and 0.03% $CO_2$)

as per manufacture guidelines. Calibration of the pneumotachometer was done via a 3 Liter calibration syringe. Maximal heart rate was defined as the highest HR recorded at any point during the test and $VO_2$max was defined as the highest 30-second value for $VO_2$ during the test. Energy expenditure was calculated from the $VO_2$ data assuming a constant of 5 kcal for each liter of $O_2$ consumed. The treadmill exercise test was completed at least 48 hours in advance of the BR session.

Prior to the BR session, subjects warmed-up on an Airdyne for 5-minutes. The BR used was 50 feet long by 1.5 inches in diameter. The workout consisted of the seven exercises listed in Table 1. Subjects practiced all of the exercises prior to being tested. For each exercise, the subject started by grasping one end of the rope in each hand with palms facing each other, feet shoulder width apart, and the knees slightly bent. Each exercise was performed twice, and the workout consisted of 15 seconds of exercise followed by 45 seconds of rest. During the rest periods, subjects were asked to sway back and forth as a form of active recovery. Exercises were presented in a random sequence for each participant. Each subject was asked to complete the test at a self-selected intensity, but were encouraged to exercise as fast and hard as possible. Heart rate was recorded throughout the workout with a Polar HR monitor, $VO_2$ was measured continuously using the Oxycon Mobile portable metabolic system, and RPE was assessed after every exercise using the 6-20 Borg Scale. Blood lactate was measured at rest and 5 minutes after the BR exercise session using a Lactate Plus Meter (Nova Biomedical, Waltham, MA). Once the BR workout was completed, subjects completed a 5-minute active recovery on the Airdyne.

Table 1. BR exercises.

| Exercises | Descriptions |
|---|---|
| Alternating arm wave (AAW) | Move both arms up and down in an alternating pattern. |
| Double arm wave (DAW) | Move both arms up and down in unison. |
| Double arm power slams (DAPS) | Bring both arms up overhead and then forcefully slam the ropes down into the ground, lowering into a deep squat when the ropes are brought down; then straighten up to return to the standing position. |
| In and out waves (IO) | Move both arms in toward one another and then back out, similar to a clapping motion. |
| Snake waves (SNA) | Move both arms side to side in unison, making the ropes look like two snakes on the floor. |
| Inward arm circles (IAC) | Move both arms in a circular pattern bringing the arms together or closer together at the top of the circle. |
| Outward arm circles (OAC) | Move both arms in a circular pattern moving both arms outward or away from each other at the top of the circle. |

## Statistical Analysis

Standard descriptive statistics were used to characterize the participant population. All values represent mean ± standard deviation. There was no significant difference between the first and second set between each exercise for $VO_2$, HR, and RPE. Thus, data for sets one and two were combined for each exercise. Differences in $VO_2$, HR, and RPE between the exercises were analyzed using a one-way ANOVA with repeated measures. Alpha level was set at $p<0.05$ to achieve statistical significance. All

analyzes were conducted using the Statistical Package for the Social Sciences (SPSS, version 25; SPSS Inc., Chicago, IL).

## RESULTS

The descriptive characteristics of the subjects who participated in this study are presented in Table 2.

Table 2. Descriptive characteristics of subjects (N=14).

| | **Mean ± SD** | **Range** |
|---|---|---|
| Age (years) | 19.6 ± 1.86 | 18 – 23 |
| Height (cm) | 178.9 ± 8.20 | 167.6 – 190.5 |
| Weight (kg) | 78.0 ± 9.59 | 62.7 – 92.7 |
| $VO_2$max (ml/kg/min) | 52.7 ± 5.86 | 39.8 – 63.4 |
| HRmax (bpm) | 186.8 ± 7.64 | 170 – 195 |

Heart rate responses to the seven different BR exercises and %HRmax are presented in Table 3. Overall, subjects exercised at an average HR of 148 ± 14.9 bpm and 79 ± 8.4% of HRmax. The average HR and %HRmax for DAPS and OAC were significantly greater than DAW and IO. The average peak HR observed for the BR exercise session was 162 ± 11.6 bpm, with an average peak %HRmax of 87 ± 6.0.

Table 3. Heart rate responses to the seven BR exercises.

| | **HR (bpm)** | **Range** | **%HRmax** | **Range** |
|---|---|---|---|---|
| IO | 144 ± 13.9 | 113 – 167 | 77 ± 7.3 | 58 – 92 |
| AAW | 148 ± 17.8 | 99 – 169 | 79 ± 9.7 | 57 – 99 |
| DAW | 144 ± 14.0 | 89 – 169 | 77 ± 9.0 | 47 – 95 |
| DAPS | 152 ± 14.8[ab] | 101 – 167 | 82 ± 9.3[ab] | 49 – 98 |
| SNA | 146 ± 16.7 | 92 – 160 | 78 ± 9.2 | 55 – 98 |
| IAC | 148 ± 12.9 | 113 – 167 | 80 ± 7.4 | 65 – 96 |
| OAC | 151 ± 13.9[ab] | 115 – 172 | 81 ± 7.1[ab] | 63 – 94 |

[a]Significantly greater than IO ($p<0.05$).
[b]Significantly greater than DAW ($p<0.05$).

Oxygen consumption responses to the seven different BR exercises and %$VO_2$max are presented in Table 4. Overall, subjects exercised at an average $VO_2$ of 26.9 ± 5.27 ml/kg/min and 51 ± 9.5% of $VO_2$max. The average $VO_2$ and %$VO_2$max for DAPS was significantly greater than all other exercises. The average peak $VO_2$ for the BR exercise session was 32.8 ± 5.38 ml/kg/min, with an average peak %$VO_2$max of 63 ± 7.5.

Table 4. Oxygen consumption responses to the seven BR exercises.

| | **$VO_2$ (ml/kg/min)** | **Range** | **%$VO_2$max** | **Range** |
|---|---|---|---|---|
| IO | 24.1 ± 5.02 | 12.5 – 34.6 | 46 ± 8.2 | 29 – 63 |
| AAW | 27.2 ± 5.72 | 16.2 – 39.8 | 52 ± 9.1 | 31 – 72 |
| DAW | 26.8 ± 5.82 | 16.0 – 37.5 | 51 ± 10.1 | 35 – 70 |
| DAPS | 30.7 ± 5.25[a] | 20.6 – 43.4 | 58 ± 9.2[a] | 37 – 78 |
| SNA | 25.8 ± 5.06 | 13.9 – 35.5 | 49 ± 9.9 | 27 – 65 |
| IAC | 26.1 ± 3.99 | 16.6 – 34.8 | 50 ± 8.9 | 32 – 63 |
| OAC | 27.4 ± 6.05 | 17.9 – 43.8 | 52 ± 11.0 | 30 – 79 |

[a]Significantly greater than all other exercises.

Rating of perceived exertion responses to the seven different BR exercises are presented in Table 5. There was no significant difference in average RPE between the BR exercises. The average peak RPE for the BR exercise session was 16.3 ± 2.01.

Table 5. Rating of perceived exertion for the seven BR exercises.

| | **RPE** | **Range** |
|---|---|---|
| IO | 14.2 ± 1.91 | 10 – 18 |
| AAW | 14.7 ± 2.19 | 10 – 18 |
| DAW | 13.7 ± 1.88 | 9 – 19 |
| DAPS | 14.9 ± 2.07 | 10 – 19 |
| SNA | 13.5 ± 1.68 | 10 – 18 |
| IAC | 14.3 ± 1.66 | 10 – 18 |
| OAC | 14.6 ± 1.78 | 10 – 18 |

Energy expenditure during the BR workout is presented in Table 6. Aerobic EE was calculated from the $VO_2$ data assuming a constant of 5 kcal per liter of $O_2$ consumed. Anaerobic EE was determined from the difference between post lactate and resting lactate values, multiplied by body weight, then by 3.3 mL $O_2$ (di Prampero & Ferretti, 1999).

Table 6. Energy expenditure during the BR workout.

| | | **Range** |
|---|---|---|
| Aerobic kcals | 130.8 ± 21.39 | 90.7 – 170.5 |
| Anaerobic kcals | 10.1 ± 4.63 | 3.5 – 17.1 |
| Total kcals | 140.9 ± 24.62 | 100.7 – 180.5 |
| Kcal/min | 10.1 ± 1.53 | 7.2 – 12.9 |

The HR response of a single subject during the BR workout is presented in Figure 1. Because each subject completed the BR exercises in a different order, a composite graph could not be generated. The boxed region represents the current ACSM guidelines for improving cardiorespiratory endurance for this participant based on his individual HRmax. The dotted line represents the delineation between moderate intensity (64%-76% of HRmax) and vigorous intensity (77%-95% of HRmax). As can be seen, there was a tendency for HR to drift upwards over the course of the BR workout.

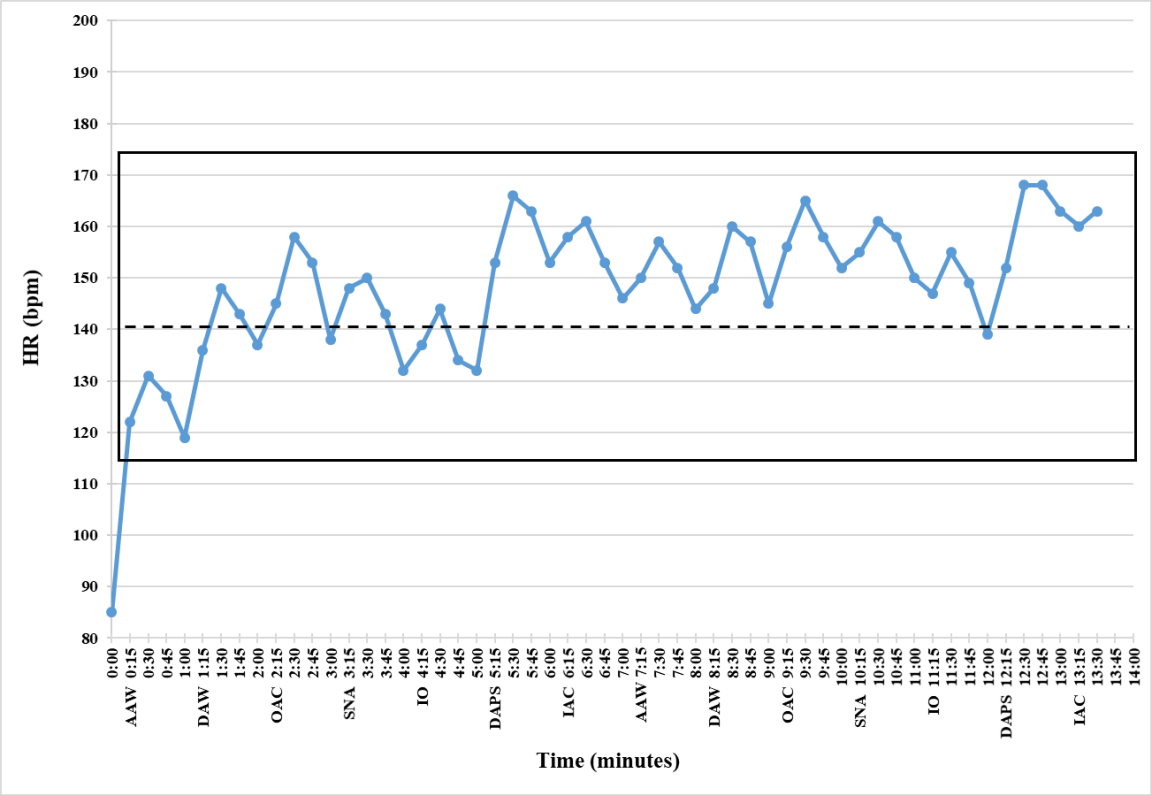


Figure 1. Heart rate response of a single participant during the BR workout.

The $VO_2$ response during the BR workout of the same subject represented in Figure 1 is presented in Figure 2. The boxed region represents the current ACSM guidelines for improving cardiorespiratory endurance for this participant based on %$VO_2$max. The dotted line represents the delineation between moderate intensity (46%-63% of $VO_2$max) and vigorous intensity (64%-90% of $VO_2$max).

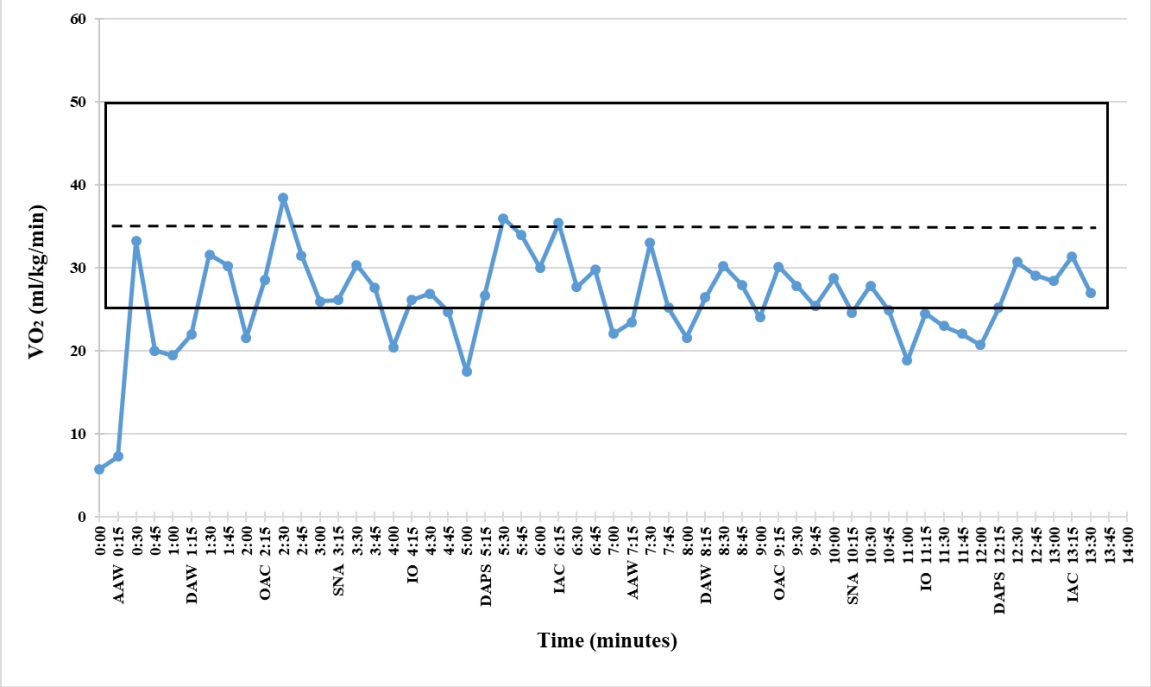


Figure 2. The $VO_2$ response of a single participant during the BR workout.

The RPE response of the same subject during the BR workout is presented in Figure 3. The boxed region represents the current ACSM guidelines for improving cardiorespiratory endurance for this participant based on RPE. The dotted line represents the delineation between moderate intensity (12-13 RPE) and vigorous intensity (14-17 RPE). It can be seen that the RPE drifted upwards continuously over the course of the BR workout.

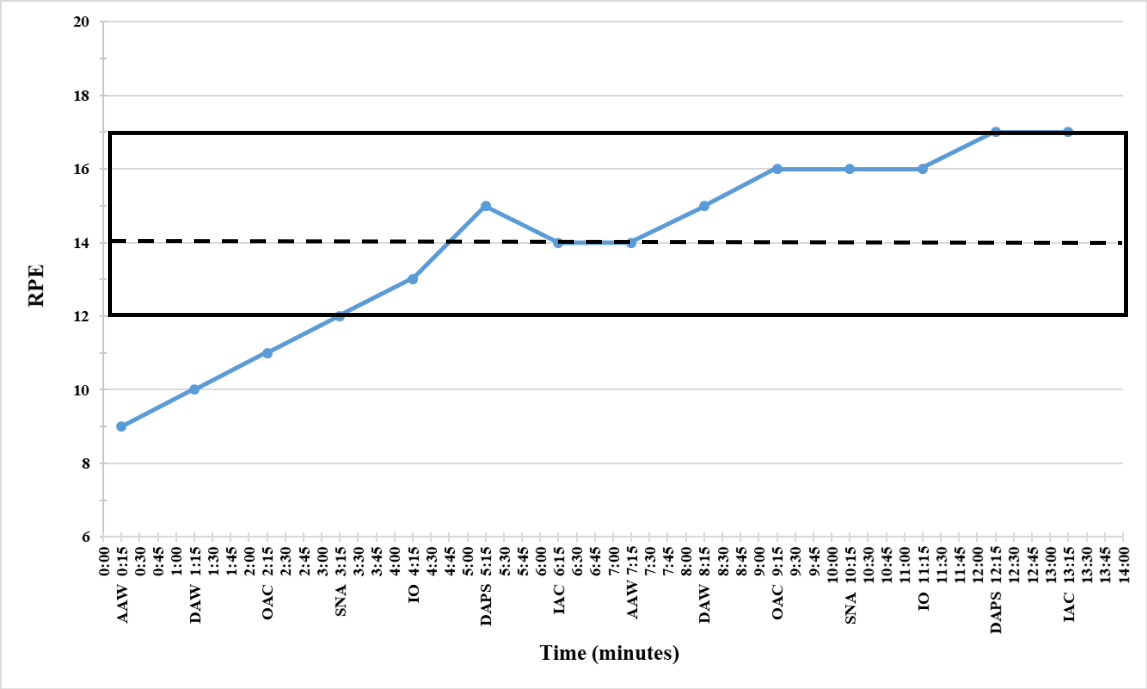


Figure 3. The RPE response of a single participant during the BR workout.

Blood lactate measurements taken at rest and at the completion of the BR workout are presented in Figure 4. Resting and post workout blood lactates were 2.9 ± 1.36 mmol and 11.8 ± 4.24 mmol respectively.

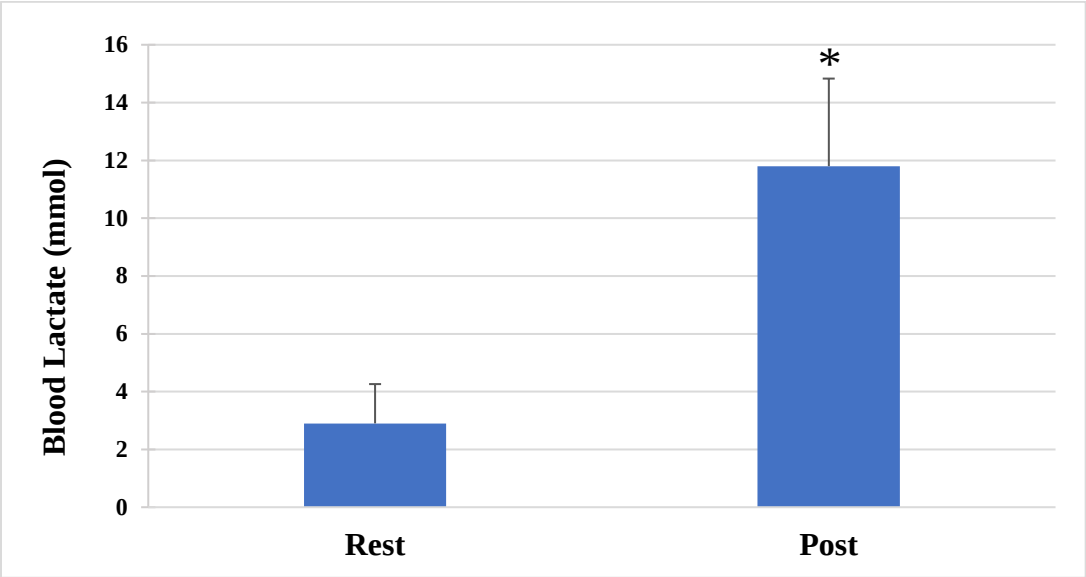


Figure 4. Blood lactate responses at rest and after the BR workout.
*Significantly greater than rest.

## DISCUSSION

The purpose of this study was to determine the relative exercise intensity and EE during a BR interval exercise session in healthy, active individuals. ACSM (2018) recommends that individuals accumulate 30 minutes of moderate intensity exercise 5 days a week or 20 minutes of vigorous intensity exercise 3 days a week in order to improve cardiorespiratory fitness. Moderate intensity exercise is defined as a HR between 64% and 76% of HRmax, a $VO_2$ between 46% and 63% of $VO_2$max, or RPE of 12-13. Vigorous intensity exercise is defined as a HR between 77% and 95% of HRmax, a $VO_2$ between 64% and 90% of $VO_2$max or RPE of 14-17.

Overall, it was found that subjects worked at an average HR of 148 ± 14.9 bpm and 79% of HRmax during the BR workout, which falls into the vigorous intensity range. The BR exercise with the highest average HR response was DAPS (152 ± 14.8 bpm), and the BR exercises with the lowest HR responses were IO (144 ± 13.9 bpm) and DAW (144 ± 14.0 bpm), respectively. Fountaine and Schmidt (2015) and Brewer et al. (2018) both performed studies on BR training and utilized identical work and rest intervals as the current study; 15 seconds of work with 45 second rest periods. However, those studies only compared the responses during DAW, whereas the current study compared the HR responses of seven different BR exercises. Fountaine and Schmidt (2015) found that during DAW, subjects had an average HR of 158 ± 14 bpm. Similarly, subjects in the study by Brewer et al. had an average HR of 157 ± 14.1 bpm during DAW. This study

found that subjects had an average HR of 144 ± 14.0 bpm during DAW which was slightly lower than the two previous studies. Peak HR response for the BR workout was 162 ± 11.6 bpm, which was 9 beats lower than the results of both Fountaine and Schmidt (2015) 171 ±11 bpm and Brewer et al. (2018) 171 ± 13.8 bpm. In the current study, average relative intensity of the workout was 79 ± 8.4% of HRmax, which again is somewhat lower than the results of Fountaine and Schmidt (2015) (86% of HRmax) and Brewer et al. (2018) (85% of HRmax). However, during all of the exercises in the current study, subjects were working at an average %HRmax of 77% which is classified as vigorous intensity exercise according to ACSM (2018) guidelines.

Overall, subjects exercised at an average $VO_2$ of 26.9 ± 5.27 ml/kg/min and 51 ± 9.5% of $VO_2$max. The BR exercise with the highest average $VO_2$ response was DAPS (30.7 ± 5.25 ml/kg/min) and the BR exercise with the lowest average $VO_2$ response was IO (24.1 ± 5.02 ml/kg/min). In the study by Brewer et al. (2018), subjects exercised at an average $VO_2$ of 21.2 ± 5.95 ml/kg/min, which is lower compared to all of the exercises in the current study, including DAW, which was the only exercise used in their study. Ratamess et al. (2015a) also measured $VO_2$ during their study on BR training, and recorded an average $VO_2$ of 24.6 ± 2.6 ml/kg/min, which is similar to the current study. Peak $VO_2$ varied considerably between studies. In the current study, peak $VO_2$ was 32.8 ± 5.38 ml/kg/min. Brewer et al. (2018) found a peak $VO_2$ of 26.6 ± 6.18 ml/kg/min and Fountaine and Schmidt (2015) recorded a peak $VO_2$ of 40.2 ± 3.0 ml/kg/min.

When comparing relative exercise intensity between studies, the %$VO_2$max was very similar, ranging from 50-52%$VO_2$max (Brewer et al., 2018, Ratamess et al. 2015a). However, in the current study, during DAPS subjects were working at an average of 58%

of $VO_2$max. Thus, if individuals want a more vigorous BR workout, they may want to include DAPS.

When looking at the relative exercise intensity data, exercising at 50-52% of $VO_2$max falls into the moderate intensity range based on ACSM (2018) guidelines. However, another way to classify exercise intensity is using METs. According to the guidelines provided by ACSM (2018), moderate intensity exercise is defined as 3.0-5.9 METs, and vigorous intensity exercise is defined as 6.0-8.7 METs. In the current study, subjects were exercising at an average $VO_2$ of 26.9 ml/kg/min, which corresponds to 7.7 METs. This falls into the vigorous category. The low relative intensity is due to the fact that subjects in the current study were relatively highly fit (average $VO_2$max of 52.7 ± 5.86 ml/kg/min) based on comparative norms (ACSM, 2018).

Peak RPE for the BR workout was 16.3 ± 2.01. Brewer et al. (2018) found a peak RPE response of 17.3 ± 2.8, which is similar to the current study. As can be seen in Figure 3, RPE rose steadily over the course of the workout. This is identical to what was found by Ratamess et al. (2015b). Although they used the Borg category ratio scale, they also demonstrated a progressive rise in RPE with each set of BR exercises. All the exercises in the current study elicited an average RPE greater than 13, with an average of 14.2 ± 1.88, which is classified as a vigorous intensity exercise according to ACSM (2018) guidelines.

During low intensity exercise blood lactate levels will remain near resting levels. As exercise intensity increases, there comes a point where blood lactate levels will start to rise, which is called lactate threshold. (Faude, Kindermann, & Meyer, 2009). Blood lactate values at the end of the BR workout were 11.8 ± 4.24 mmol. Fountaine and

Schmidt (2015) found similar blood lactate values (11.9 ± 1.4 mmol). Ratamess et al. (2015b) also found higher blood lactate values after a BR workout compared to baseline. They recorded average blood lactate values of 13 mmol which, was higher than the current study. This is most likely due to the fact that they utilized 30-second work bouts verse 15-second work bouts in the current study.

For EE, it is recommended that individuals expend 1,200-2,000 kcal per week (240-400 kcal per exercise session) in order to have a positive effect on body composition (Donnelly et al., 2009). The average EE in the current study was 10.1 ± 1.53 kcals/min. This value was simular to the results of Fountaine and Schmidt (2015) who also found an average EE of 9.9 ± 3.4 kcals/min. This result is also similar to the findings of Ratamess et al. (2015b) (10.3 ± 1.4 kcals/min), despite the fact that subjects in their study performed 30-second work bouts. The total number of kcals burned during the BR exercise session was 138.0 ± 24.70, which is below the recommended guidelines for positively affecting body composition. However, this was solely due to the short nature of the workout (14 minutes).

Possible limitations of the current study include that there are many different ways to structure a BR workout. Longer exercise intervals and/or shorter rest periods could affect the intensity of a BR exercise session. Different ranges in length and thickness of the BR can also affect the intensity. There are also other types of BR exercises that were not studied. Additionally, we did not measure the number of oscillations during each interval, and instead encouraged subjects to exercise as fast and hard as possible. Another limitation was that the participants were young, active males. Responses in females, older, or more sedentary individuals could provide different

responses. Thus, further research could be conducted in other populations to evaluate the CR responses and relative exercise intensity of different BR exercise sessions.

## CONCLUSION

In summary, we found that a BR exercise session does meet ACSM (2018) guidelines for improving CR endurance. The average HR response and average RPE response showed that a BR exercise session meets the guidelines for a vigorous intensity exercise. However, the average $VO_2$ response showed that a BR exercise session meets the guidelines for a moderate intensity exercise. It was also found that based on HR and $VO_2$ responses, DAPS seem to be the exercise with the highest metabolic response. The average total kcals burned during the BR exercise session did not meet the recommendation for EE and positive effect on body composition. A BR exercise session can be very versatile, but it could be an option for an exerciser trying to improve CR endurance.

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# APPENDIX A

# INFORMED CONSENT FORM

## Informed Consent

### Energy Expenditure and Relative Exercise Intensity of a Battle Rope Interval Exercise

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

**Purpose and Procedures**

- The of this study is to determine whether a battle rope interval exercise meets the American College of Sports Medicine's guidelines for improving cardiorespiratory fitness.
- Battle ropes come in various lengths and diameters and are anchored at a fixed point, and through various movements waves are created.
- My participation in this study will consist of two separate sessions.
- The first session will be a maximal exercise test on the treadmill. The test will start out at a low level and the workload will gradually increase until I can no longer continue. During this test I will breathe through a mask to analyze my expired air and wear a chest strap to measure my heart rate. I will also be asked to rate my subjective exertion at the end of each stage and at maximal exertion.
- The next session will consist of a battle rope interval exercise. During the exercise, I will wear a mask to analyze my expired air and wear a chest strap to measure my heart rate. I will be asked to rate my subjective exertion at the end of each interval. I will get a pinprick on the finger to get a blood lactate measurement at rest and at the end of the battle rope exercise.
- Testing will take place in Mitchell Hall and the wresting facility on the UW-L campus.
- Research assistants will be conducting the research under the direction of Dr. John Porcari, a professor in the department of Exercise and Sport Science.

**Potential Risks**

- I may experience substantial overall muscle fatigue, shortness of breath, and muscle soreness because of the exercise performed in the current study.
- Minor injuries and pulled muscles may occur as with any other high intensity workout.

- The risk of serious or life-threatening complications (i.e. heart attack, stroke, death) is very low in healthy, regularly exercising adults, but always a possibility of any exercise.
- The test will be stopped immediately upon the development of any complications.
- There will be persons trained in CPR, AED, and Advanced Cardiac Life Support available for every testing session and an AED is present in the laboratory.

**Benefits of Participation**

- By participating, I will gain a better understanding of my physical fitness level.
- This study will also be important for exercise professionals, researchers, and the general public who are interested in the effectiveness of cardiorespiratory fitness doing a battle rope interval exercise.

**Rights and Confidentiality**

- My participation is voluntary.
- I may choose to discontinue my involvement in this study without penalty at any time.
- The results of this study have the potential of being published or presented at professional meetings, however, only group data will be presented.

I have read the information provided on this consent form. I have been informed the purpose of this study, procedures, the expectation for myself as well as the testers, and any potential risks and benefits that could be associated with volunteering for this study. I have asked all questions, if any, that concerned me and received clears answers to fully understand all aspects of this study.

Concerns about any aspects of this study may be directed to Kacey Iwen (715-612-3512), the principal investigator, or her advisor Dr. Porcari at (608-785-8684), a professor in the Department of Exercise and Sport Science. Questions about the protection of human subjects may be addressed to Dr. Bart Vanvoorhis (608-785-6892), Chair of the UW-L Institutional Review Board for the Protection of Human Subjects.

Participant's Name (Print):_____

Participant's Signature:_____ Date:_____

Researcher's Signature:_____ Date:_____

APPENDIX B

PAR-Q FORM

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)

# PAR-Q & YOU

**(A Questionnaire for People Aged 15 to 69)**

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

| YES | NO | | |
|---|---|---|---|
| ☐ | ☐ | 1. | **Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?** |
| ☐ | ☐ | 2. | **Do you feel pain in your chest when you do physical activity?** |
| ☐ | ☐ | 3. | **In the past month, have you had chest pain when you were not doing physical activity?** |
| ☐ | ☐ | 4. | **Do you lose your balance because of dizziness or do you ever lose consciousness?** |
| ☐ | ☐ | 5. | **Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?** |
| ☐ | ☐ | 6. | **Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?** |
| ☐ | ☐ | 7. | **Do you know of any other reason why you should not do physical activity?** |

## If you answered YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

## NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

**DELAY BECOMING MUCH MORE ACTIVE:**

- If you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- If you are or may be pregnant – talk to your doctor before you start becoming more active.

**PLEASE NOTE:** If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.



NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME _____

SIGNATURE _____ DATE _____

SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority) _____ WITNESS _____

**Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.**



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continued on other side...

# APPENDIX C

# DATA COLLECTION FORM

**Treadmill**

Name:_____ Subject #:_____

Age:_____years Height:_____in

Weight:_____lb Weight:_____kg

Testing Session Date: _____ Time: _____

Speed: _____mph

| Time | Grade | RPE | HR | $VO_2$ |
|---|---|---|---|---|
| 0:00-2:00 | 0.0% | | | |
| 2:00-4:00 | 2.5% | | | |
| 4:00-6:00 | 5.0% | | | |
| 6:00-8:00 | 7.5% | | | |
| 8:00-10:00 | 10.0% | | | |
| 10:00-12:00 | 12.5% | | | |
| 12:00-14:00 | 15.0% | | | |
| 14:00-16:00 | 17.5% | | | |
| 16:00-18:00 | 20.0% | | | |
| 18:00-20:00 | 22.5% | | | |
| 20:00-22:00 | 25.0% | | | |
| 22:00-24:00 | 27.5% | | | |
| 24:00-26:00 | 30.0% | | | |

Comments:

_____

_____

**Battle Rope**

Name:_____ Subject #:_____

Height: _____in Weight:_____lb Weight:_____kg

Lactate Rest: _____mmol/L Lactate Post BR: _____mmol/L

Testing Session Date: _____ Time: _____

| BR Exercise | RPE | HR | $VO_2$ |
|---|---|---|---|
| | | | |
| | | | |
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Comments:

_____

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# APPENDIX D

# BORG RPE SCALE

| Rating | Perceived Exertion |
|---|---|
| 6 | No exertion |
| 7 | Extremely light |
| 8 | |
| 9 | Very light |
| 10 | |
| 11 | Light |
| 12 | |
| 13 | Somewhat hard |
| 14 | |
| 15 | Hard |
| 16 | |
| 17 | Very hard |
| 18 | |
| 19 | Extremely hard |
| 20 | Maximal exertion |

# APPENDIX E

# REVIEW OF LITERATURE

## What are Battle Ropes?

According to a survey of the top 20 worldwide fitness trends for 2018, high intensity interval training (HIIT) was number 1 on the list (Thompson, 2017). Battle rope (BR) workouts usually are in the form of HIIT. High intensity interval training is characterized by a few bursts of all out exercise alternating with either complete or active rest (Gibala & Shulgan, 2017). According to Gibala and Shulgan (2017), HIIT might be the most effective workout that has ever been developed because it can be done in less time than endurance training and is shown to improve aerobic fitness and other health benefits associated with endurance training.

Battle ropes are generally 30-50 feet in length and 1.5 inches and 2 inches in diameter (Stanforth, Brumitt, Ratamess, Atkins, & Keteyian, 2015). Battle ropes are anchored at a secured point (e.g. kettle bell, fence post, tree), and through multiple types of movement patterns, waves are created (Stanforth et al., 2015). The range of people that use battle ropes range from beginners to professional athletes. Beginners are recommended to start with a small rope and progress to a larger, thicker ropes as the movements become easier. It is also recommended beginners start with basic movements such as single-arm alternating waves and double-arm waves and progress to more complex movements. Beginners are recommended to start out with a low number of repetitions (15 to 20 reps per set) or set duration (15 to 20 seconds) and a rest time between 30 seconds to 2 minutes between sets to maintain proper form/technique and volume. Once the exercise becomes easier, increasing repetitions and set duration or decreasing rest intervals to where little rest is allowed between sets, to where the workout becomes more continuous (Stanforth et al., 2015).

## Recommendations for Physical Activity

The American College of Sports Medicine (ACSM) has developed physical activity guidelines for improving cardiorespiratory fitness. ACSM recommends that healthy adults participate in moderate intensity activity for 30 minutes a day, 5 days a week or vigorous intensity activity for 20 minutes a day, 3 days a week. It is recommended that individuals need to exercise 46-90% of $VO_2$max and 64-95% of HRmax in order to improve cardiorespiratory endurance (ACSM, 2018). Expending 1,000 kcals during the week ends up being equivalent to 30 minutes of physical activity a day or 150 minutes of physical activity per week. There are many health benefits that come from physical activity, including but not limited to improvement in cardiorespiratory function, reduction in cardiorespiratory risk factors, decreased morbidity, decreased anxiety and depression, improvement in cognitive function, and enhanced feeling of well-being (ACSM, 2018).

## Lactate

Lactic acid is broken down into lactate and hydrogen ions during anaerobic glycolysis. Anaerobic glycolysis is the transformation of glucose to lactate during exercise when limited amounts of oxygen ($O_2$) are available. During low intensity exercise blood lactate levels will remain near resting levels. As the exercise intensity increases there comes a point where blood lactate levels will start to rise. This is called lactate threshold (Faude, Kindermann, & Meyer, 2009). In response to “all-out” maximal exertion, peak lactate values may be observed 3–8 minutes post exercise (Goodwin, Harris, Hernández, & Gladden, 2007).

## Current Research on Battle Rope Training and Cardiorespiratory Response

There are a limited number of studies that have investigated the responses to BR training. A study by Fountaine and Schmidt (2015) investigated the physiological response to one session of BR training. One BR exercise, double arm waves, was completed for 15 seconds with 45 seconds of rest between sets with a total of ten reputations. They found that subjects were exercising at 86% of age-predicted HRmax, which falls into the range for improving cardiorespiratory endurance.

A different study by McAuslan (2013) examined $VO_2$ and number of push-ups and sit-ups performed before and after a four-week BR training series. Subjects trained three times a week at 80% of HRmax, which was predicted based upon age. The training consisted of a 30-second interval exercise, alternating between the double-whip and alternating-whip battle rope movements, separated by 60 seconds of rest for 10 total rounds. Females increased their $VO_2$max, average peak $VO_2$, and the maximal number of push-ups and sit-ups performed. Males saw no change in $VO_2$max and on maximal sit-ups, but did increase maximal number of push-ups performed. It was concluded that a BR training series shows potential to improve aerobic and anaerobic parameters over 4 weeks.

Chen et al. (2018) performed an 8-week BR training series on collegiate basketball players. The study investigated whether BR training compared to regular training (shuttle running) enhances aerobic capacity, upper-body power, lower-body power, core endurance, and shooting accuracy. Subjects were divided into a BR training group or a shuttle run group. Both groups participated in 3 sessions per week for 8 weeks. Both groups exercised 3 times per week and completed the same number of sets, exercise

time, and rest interval time. It was found that the BR training group enhanced aerobic capacity, upper-body power, lower-body power, core endurance, and shooting accuracy. Yet, the shuttle run group only increased aerobic capacity and upper-body power.

A study by Brewer et al. (2018) compared the $VO_2$, HR, and RPE responses during a BR workout in a seated versus a standing position. The subjects in the seated BR workout group performed a bicycle $VO_2$max test while the subjects in the standing BR workout group performed a treadmill $VO_2$max test. Both BR workouts consisted 10 sets of double arm waves with each set consisting of 15 seconds of work follow by 45 seconds of rest. It was found that %$VO_2$max performing BR exercises while sitting (52.3% of $VO_2$max) verse standing (51.9% of $VO_2$max) was similar. It was found that %HRmax while performing BR exercises while sitting (82.1% of HRmax) verse standing (85.1% of HRmax) was also similar. The subjects in both protocols worked at a moderate intensity exercise according to their $VO_2$ responses. However, it was found that the subjects in both protocols worked at a vigorous intensity exercise according to their HR responses. The authors also found that peak RPE was almost identical in the seated (17.7 ± 1.52) verse standing (17.3 ± 2.8) protocols. It was concluded that BR performed in the sitting or standing position are very similar in metabolic responses and can improve cardiorespiratory fitness.

Ratemass et al. (2015) compared a BR circuit to other types of resistance training exercises. Thirteen resistance exercises were performed on separate days: seven free weight, five body weight, and a BR circuit. For the free weight exercise protocols, subjects performed 3 sets of 10 repetitions with 75% of their 1 repetition maximum. Multiple sets and repetitions were used for the body weight exercises. For the push-up

and push-up on a BOSU ball protocols, subjects performed 3 sets of 20 repetitions. For the burpee and push-up with lateral crawl protocols, subjects performed 3 sets of 10 repetitions. For the plank and BR circuit protocols, subjects performed 3 sets of 30-second bouts. The BR circuit consisted of three exercises performed for 10 seconds each, for a total of 30 seconds. A standard 2-minute rest interval was used between all sets for each exercise. It was found that subjects were working at 80% of $VO_2$max for the BR circuit, which is considered vigorous intensity exercise according to ACSM guidelines. The battle rope protocol had the largest $VO_2$ (24.6 ± 2.6 ml/kg/min), HR (153.5 ± 13.9 bpm), and EE (10.3 ± 1.4 kcals/min) responses compared with all exercises tested.

Another study by Ratemass et al. (2015) investigated the effects of rest interval during BR training. Two exercise series were performed on different days, one with 1-minute rest interval and one with 2 minutes rest interval. Blood lactate was taken before and after each battle rope series; both were significantly higher than baseline, but 1-minute rest interval blood lactate was higher. $VO_2$ was taken through the whole exercise and values were higher in 1-minute rest interval (27.0 ± 3.3 ml/kg/min) compared to 2-minute rest interval (20.7 ± 2.5 ml/kg/min). Subjects during the 1-minute rest interval worked at 52.8 ± 5.5% of $VO_2$max which is considered moderate intensity exercise. However, when the subjects performed the 2-minute rest interval worked at 40.5 ± 4.5% of $VO_2$max which is considered light intensity exercise. Energy expenditure for the 1-minute rest interval (35.9 ± 5.1 kcals/min) was relatively the same as the EE for the 2-minute rest interval (32.6 ± 4.0 kcals/min). The authors concluded that a BR interval exercise with shorter rest intervals has a greater effect on cardiorespiratory fitness and the same metabolic response compared to longer rest intervals.

## Conclusion

The goal of this paper was to review the literature related to the $VO_2$, HR, and EE responses to BR exercises. However, there has been a limited number of studies researching this topic. Based upon the studies in the current research, BR training falls into the range of improving cardiorespiratory endurance (Brewer et al. 2018, Fountaine & Schmidt, 2015, Ratemass et al., 2015).

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