ORIGINAL RESEARCH

RELATIVE INTENSITY OF TWO TYPES OF CROSSFIT EXERCISE: ACUTE CIRCUIT AND HIGH-INTENSITY INTERVAL EXERCISE

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ABSTRACT

Introduction: CrossFit® training sessions are often performed using either high-intensity continuous (circuit) or interval training (HIIT) methods and have been shown to elicit large increases in cardiovascular fitness. The acute responses of these different types of workouts, however, have not been reported. The purpose of this preliminary study was to a) describe and compare the heart rate (HR) and perceived exertion (RPE) responses to two different CrossFit-based multimodal exercise sessions: circuit (MMCIR) and high-intensity interval (MMHIIT) sessions; and b) examine the differences in responses by novice compared to experienced participants.

Methods: HR and RPE data from fifty-seven participants (38 female) who completed both sessions of MMHIIT and MMCIR on separate days were recorded. MMHIIT was 6 sets of 60 second all out intervals interspersed with 3 minutes of rest. Each interval consisted of 8 heavy bench presses (~70% of 1RM), 10 pull-ups, and repetitive box jumps for the remainder of the 60 seconds. MMCIR was a continuous session where participants completed as many circuits as possible in 21 minutes, where each circuit consisted of 5 pull-ups, 10 push-ups, and 15 body weight squats.

Results: For the whole study population, mean HR responses during MMHIIT (76 ± 7%predmax) were significantly lower than that during MMCIR (88 ± 6%predmax), despite similar RPE scores (17 ± 2 vs 18 ± 1 / 20, respectively). Experienced participants (n = 22) had a higher overall HR than the novice group (n=35) during both MMCIR and MMHIIT sessions with greater indices of work performance, but no differences in RPE.

Conclusions: The relative intensity of each CrossFit session was considered to be at the high end of the guidelines for exercise prescription for health and fitness and may be effective for inducing increased cardiovascular fitness. The results of this study provide much needed information related to the physiological responses to relatively new high-intensity multimodal training methods such as CrossFit.

Keywords: CrossFit, HIIT, Circuit training, Resistance training, Sprint intervals, Cardiovascular responses.
INTRODUCTION

Current recommendations for achieving health and fitness benefits from exercise require a moderate exercise intensity (64-76% of heart rate maximum) for 40-50 minutes, five times per week, or vigorous (76-96% of heart rate maximum) for 20 minutes, three times per week.¹ There is an increasing recognition that time constraints on many individuals beginning an exercise program prohibit the former recommendation and lesser time demands may be more appropriate. In addition, it is well known that higher intensities of exercise result in greater health, fitness, and performance benefits.²-⁵ Compared with moderate intensity, vigorous intensity exercise (particularly high-intensity interval training or HIIT) is relatively safe, ⁶-⁸ enjoyable, ⁹,¹⁰ and effective in inducing at least similar aerobic adaptations ¹¹,¹² and greater anaerobic adaptations.¹³ This type of exercise training has also been shown to be beneficial for reducing cardiovascular disease risk, morbidity, and mortality.² The mode of training, however, is usually suggested to be whole body, continuously cycling (mono-structural) movements such as walking, running, swimming, or cycling and does not, in most individuals, result in increased muscle strength or power.¹⁴ There is very little known regarding the use of other modes of exercise training, such as resistance-based or multimodal training, for attaining the intensities associated with the above noted cardiovascular and aerobic benefits. Multimodal training involves combining multiple modalities, such as resistance exercises, power exercises, and/or conditioning exercises, usually within a circuit format. While there is some evidence to support a cardiovascular response to continuous circuit training, the relative intensity that has been used to prescribe this exercise is usually low to moderate.¹⁵,¹⁶ In addition, resistance training using functional movement patterns and longer rest periods has been shown to have a significant effect on muscle strength and power; however, typically does not elicit a sustained heart rate response.¹⁷ In order to achieve gains in muscle strength and power at the same time as gains in aerobic and anaerobic performance, multiple training methods are usually employed; however typical structured programs result in increased time demands. There is limited evidence that extremely low volume, body weight multimodal HIIT exercise may be as effective as continuous aerobic training in inducing aerobic gains, and superior for gains in muscle endurance;¹⁰ however this mode of training has not been investigated extensively.

One popular example of multimodal HIIT training is CrossFit® (a registered trademark of CrossFit, Inc). CrossFit is a relatively new, but extremely popular, multimodal form of exercise training that incorporates many types of high-intensity, functional movement patterns and is often performed in a circuit format with short rest (interval training) or no rest (continuous training) periods between exercises or groups of exercises.¹⁸ CrossFit training has been shown to be extremely effective for inducing improvements in cardiovascular fitness and body composition in trainees of all levels of fitness.¹⁹ CrossFit has also been criticised for its lack of conformity to established training principles,²⁰ but there is very little information available regarding the specific exercise responses to different types of CrossFit training and how they fit with established guidelines. The combination of the aerobic, anaerobic, and resistance training within each session of training make CrossFit an intriguing training method to achieve multiple physiological and performance adaptations in novice exercisers and more experienced athletes alike; however, to our knowledge, the acute effects of this form of multimodal continuous and HIIT have not been reported in either population.

The objectives of this exploratory study were to: 1) describe and compare the heart rate (HR) and rate of perceived exertion (RPE) responses to two CrossFit exercise sessions; one multimodal continuous circuit (MMCIR) and the other multimodal high-intensity interval training (MMHIIT), and 2) compare the HR and RPE responses to these types of sessions between individuals with significant CrossFit training experience with those who are more novice.
METHODS

Study Design

This study was an observational, cross-sectional study examining the heart rate and rate of perceived exertion responses to two different multimodal CrossFit exercise sessions. Each session was held on separate days, with at least 48 hours between sessions. Testing sessions were held in groups of 6-12 participants spread across a single day of testing for each exercise; therefore, sessions were not randomised. All participants, however, including the Novice participants, had previous experience with each type of exercise bout to minimise any order effect.

Participants

Potential participants were recruited from a registered CrossFit affiliate and had completed a four-week “onramp” program with at least one additional month of experience with CrossFit training. Novice participants were defined as those with one to eight months of experience, whereas experienced participants had greater than eighteen months of CrossFit experience. Trainees with nine to seventeen months of experience were excluded from participation in the study. These timelines were selected to ensure a significant gap in experience level between the two groups of participants. Following explanation of the study (which was approved by the University Biomedical Ethics Review Board), 64 participants stated they were free from any exercise-limiting medical or musculoskeletal condition and consented to participation in the study. Of the 64 participants, 62 completed both sessions. The two participants who withdrew did so due to time constraints. The heart rate data on five participants was unusable due to equipment failure; therefore, heart rate data was recorded on 57 participants. Participant age, height, weight, and amount of experience with CrossFit training were recorded. Participant characteristics are presented in Table 1.

Table 1. Participant Characteristics

<table>
<thead>
<tr>
<th></th>
<th>EXP</th>
<th>NOV</th>
<th>ALL</th>
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<tbody>
<tr>
<td>Number (n)</td>
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<td>35</td>
<td>57</td>
</tr>
<tr>
<td>Age (years)</td>
<td>32.6 (9.8)</td>
<td>30.7 (8.5)</td>
<td>31.4 (9.5)</td>
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<td>Male:FEMALE (n)</td>
<td>7:15</td>
<td>12:23</td>
<td>19:38</td>
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<tr>
<td>Experience (months)</td>
<td>30.7 (10.3)</td>
<td>5.4* (3.9)</td>
<td>16.5 (14.8)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>169 (9.5)</td>
<td>172 (9.8)</td>
<td>171 (9.5)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>73.6 (13.1)</td>
<td>76.6 (13.0)</td>
<td>75.2 (12.3)</td>
</tr>
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</table>

Mean (sd). *p < 0.05 vs. EXP within each session. EXP – experienced group, NOV – novice group.

Procedures

All testing was completed at a registered CrossFit affiliate under the supervision of a Level-one or greater CrossFit trainer, which indicates that the trainer has met the competency to ensure sessions were completed to the standards outlined by CrossFit, Inc. Participants were asked to refrain from smoking, alcohol consumption, and caffeine consumption for at least four hours prior to testing. On each day of testing, subjects were fitted with a heart rate monitor (T61, Polar Electro Canada, Lachine, QC). Prior to testing for each session, participants completed a CrossFit Trainer-led standardised dynamic warm-up, which consisted of a 400 meter run and various dynamic stretches for the upper and lower body. The dynamic warm up was approximately 10 minutes and was instructed to...
Figure 1. Bench press technique progression used for the MMHIIT session.

Figure 2. Pull up and ring row technique for both the MMHIIT and MMCIR sessions. a) kipping pull up progression b) ring row progression. Participants used the kipping pull up if they were able to for each complete session, but used the ring row if they could not.

Figure 3. Box jump technique progressions used for the MMHIIT session.
be completed at a moderate degree of effort. Following the warmup, participants were provided with workout instructions, specific practice of the movements for each session, and an exercise-specific warmup of the exercises requiring loading. This specific aspect of each session was completed in approximately 20 minutes and at a level of effort progressing from light-moderate to heavy to reach approximately 8 repetitions of the loaded movement nearing, but not reaching, failure in the final warm up set. During each study session, HR was recorded in 5 second averages and uploaded to a computer upon completion of each session for later analysis.

Multimodal high-intensity interval training (MMHIIT) session

The MMHIIT session consisted of 6 sets of 60 second intervals, performed at all-out intensity, with 3 minutes of rest between intervals, for a total of 21 minutes. Each interval consisted of 8 fast velocity barbell bench presses at approximately 70% of previously determined one repetition maximum (1RM), 10 kipping pull-ups or ring rows, and repetitive moderate height box jumps for the remainder of the 60 seconds. The movement patterns for this session were chosen to be similar to the movement patterns in the MMCIR session (bench press being similar to push-ups, box jumps being similar to body weight squats, and pull-ups or ring rows being equivalent between sessions). The intent of this session was to achieve a high metabolic demand and to perform each component of the session as fast as possible, with proper technique (as described below).

**Bench press:** Barbell bench press load was set by estimating 1RM using previously obtained bench press RM loads and the equation 1RM = (weight used x number of repetitions x 0.0333) + weight used. The loads used to calculate 1RM for this study were obtained by participants during a previous testing session held prior to the study, but were supervised and standardised by a Level-one or greater CrossFit trainer. Bench press technique was monitored such that both feet remained on the floor, the hips remained on the bench, and the bar was fully lowered to the chest and fully raised such that the elbows were fully extended (Figure 1). Bar grip was at each participants’ usual width, but generally was just wider than shoulder width.

**Pull-ups or ring rows:** Pull-ups were completed on a high bar rig (Rogue Fitness, Columbus, OH) and were scaled based on each participant’s current abilities as described below. Participants were asked to complete the session at the highest level of performance (ie. the least level of scaling) possible to be maintained for the entire session. As each participant had experience with all of these exercises, the level of scaling was determined prior to study entry. The highest loading was body weight pull-ups, using a kipping or butterfly technique, and participants were instructed to raise their chin above the horizontal plane of the high bar and to completely lower to full elbow extension at the bottom of the movement. Kipping and butterfly pull-ups use whole body swinging momentum to assist with the elevation of the body toward the pull-up bar (Figure 2a). When participants could not complete pull-ups, this movement was replaced with ring rows. Ring rows involve subjects performing a horizontal, body weight-loaded row with the heels on the ground behind the vertical plane of the rings, and the rings at mid-torso height (Figure 2b). Technique was monitored and participants were instructed to maintain neutral body position while rowing.

**Box jumps:** The box jumps (Figure 3) were completed using a moderate height for each participant, such that the jumps were subjectively difficult, but participants were able to perform repetitive jumps (without a pause at the top of the box or upon landing on the floor). In general, a moderate height was determined to be approximately the distance from the floor to just below participants’ patella’s. Participants started on the ground, facing the box, and jumped onto the box. They completed the ascent by standing completely on the box with full hip extension. Emphasis was placed upon completing the interval as fast as possible, but with proper technique for the entire 60 seconds of each interval, and minimising the transition time between movements.
Figure 4. Technique progressions for the push up and the different levels of scaling used in the MMCIR session. Participants used the full push up (a) if they were able to for the complete session, but used the knee push up (b), the eccentric-knee push up (c), or low bar push up (d) if they were not.
Rate of perceived exertion using a Borg category 6-20 scale\textsuperscript{23} was recorded at the end of each interval.

**Multimodal Circuit (MMCIR) session: Modified Cindy**

The second exercise session was a multimodal continuous exercise session modified from the CrossFit benchmark workout called “Cindy” (CrossFit, Inc.). Participants completed as many repetitions as possible in rounds of 5 pull-ups, 10 push-ups, and 15 body weight full squats for the total session time. Whereas “Cindy” is performed for 20 minutes, our protocol was completed for 21 minutes to match the time required for the MMHIIT session.

**Pull-ups:** Pull-ups and scaling were the same as for the MMHIIT session. Participants used the same technique and scaling for MMCIR pull-ups as in the MMHIIT session (Figure 2a and 2b).

**Push-ups:** As with the pull-ups, the push-ups were scaled based on each individual’s abilities and maintained for the duration of the session. Full push-ups were completed with only the toes and the hands on the ground. Bottom position was with the chest (but not the hips) touching the floor and top position was with the elbows fully extended (Figure 4a). Push-ups were scaled by replacing the toes with the knees as the pivot point (Figure 4b), by doing a full eccentric push-up, then dropping the knees to the floor for the concentric phase (Figure 4c), or by raising the hands onto a low box or bar (Figure 4d).

**Squats:** Full body weight squats were completed such that the hips were lowered below the knees at the bottom position and were fully extended at the top position (Figure 5). Squats were only scaled for participants with limited range of motion at the ankle, whereby they were allowed to place their heels on a low wooden board.

Participants were encouraged to complete as many circuits as possible in the 21 minutes. The number of circuits completed was converted to repetitions (30 repetitions per circuit) and the extra repetitions completed at the time limit over and above the target number were counted.

![Figure 5. Body weight squat progressions for the MMCIR session.](image)

![Figure 6. Comparison of overall mean heart rate responses to MMCIR and MMHIIT. Shaded time represents the 60 second work intervals in the MMHIIT session. * Significant difference in the average heart rate responses between sessions (p = 0.00).](image)
above the total number of circuits were added to the repetition total. Rate of perceived exertion was recorded after 1, 5, 9, 13, 17, and 21 minutes (at the time corresponding to the same time RPE was recorded during the MMHIIT session).

Statistical Analysis
Heart rate data were normalised to a percent of predicted maximum using the equation $220 - \text{age}$. Heart rate data for both exercise sessions were averaged into 20 second blocks, giving 63 blocks across each 21 minute time period. In addition, the overall average heart rate for each individual was calculated across the entire 21 minutes for each session. For objective 1, descriptive data for each session are presented as mean and standard deviations. Prior to the initiation of the statistical analyses below, the degree of skewness and kurtosis was assessed to be each less than ± 2.0 and the data deemed parametric. In addition, preliminary analysis of our data for gender bias found no significant difference between genders for our HR and RPE data across any of the comparisons, and therefore, data for both genders was combined for the full analyses. Paired t-tests were used to compare the overall average heart rate across the entire 21 minutes and RPE at each of the six data collection points between each session. For objective 2, HR and RPE across the six data collection points were compared between experienced and novice CrossFit participants using a repeated measures 2x6 (group x time) ANOVA for each of the MMCIR and MMHIIT sessions. Where significant main effects were observed, a Tukey’s post hoc analysis was performed. For all analyses, alpha was set at 0.05.

RESULTS

Exercise Session Scores
Table 2 shows the scores and scalings for each group of participants during each workout.

Comparison between MMHIIT and MMCIR:
Figure 6 shows the HR responses to both MMHIIT and MMCIR. For the MMHIIT session, peak heart rate in the last 20 seconds of each interval increased from $84.5 \pm 8.14$ %predmax in the first interval to $88.3 \pm 7.30$ %predmax in the last interval. For the MMCIR session, HR increased over the first 3-4 minutes until an approximate steady state was reached. Steady state continued until approximately the 18th minute, when HR increased up to a peak at $93.0 \pm 6.20$ %predmax during the last minute. For the MMCIR session, HR increased over the first 3-4 minutes until an approximate steady state was reached. Steady state continued until approximately the 18th minute, when HR increased up to a peak at $93.0 \pm 6.20$ %predmax during the last minute. For the MMCIR session, HR increased over the first 3-4 minutes until an approximate steady state was reached. Steady state continued until approximately the 18th minute, when HR increased up to a peak at $93.0 \pm 6.20$ %predmax during the last minute. Overall average HR response across the entire 21 minute exercise session was significantly higher during MMCIR than MMHIIT ($87.6 \pm 5.6$ vs. $76.4 \pm 7.3$%pred max; $p = 0.01$). There were no differences between the peak HR achieved during the final 20 second block of each MMHIIT interval.
and the HR during the corresponding block during MMCIR (p-values ranging from 0.54 to 0.97). RPE was similar between sessions (Table 3).

**Effect of experience on MMCIR**

Figure 7 shows the HR responses to MMCIR in experienced and novice practitioners. The experienced group showed a significantly higher mean HR response (main effect; $p = 0.00$), likely reflecting a higher work rate in this group (Table 2). RPE was similar between groups (Table 3).

**Effect of experience on MMHIIT**

Figure 8 shows the HR responses to MMHIIT in experienced and novice practitioners. The experienced participants tended to exhibit a higher mean HR response across the session, as well as a significantly higher HR response during recovery (main effect; $p = 0.01$). RPE was similar between groups; with the experienced group tending to exhibit slightly higher scores (Table 3).

**DISCUSSION**

The primary aim of this study was to compare the HR and RPE responses to two types of multimodal, CrossFit exercise sessions, utilising resistance-based movement patterns as opposed to more cyclical, mono-structural exercise movement patterns such as running, cycling, or rowing. The primary results of this study showed that both the multimodal high-intensity interval exercise

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**Table 2. Bench press loads, movement scalings, and performance scores of the MMCIR session**

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<tbody>
<tr>
<td><strong>Bench press load used in MMHIIT (kg)</strong></td>
<td>75 (18)</td>
<td>42* (19)</td>
<td>51 (18)</td>
</tr>
<tr>
<td><strong>Pull up scaling used in both sessions (n)</strong></td>
<td>Full – 17</td>
<td>Full – 18</td>
<td>Full – 35</td>
</tr>
<tr>
<td></td>
<td>RR – 5</td>
<td>RR – 17</td>
<td>RR – 22</td>
</tr>
<tr>
<td><strong>Push up scaling used in MMCIR (n)</strong></td>
<td>Full – 16</td>
<td>Full – 18</td>
<td>Full – 34</td>
</tr>
<tr>
<td></td>
<td>Mod – 6</td>
<td>Mod – 17</td>
<td>Mod – 23</td>
</tr>
<tr>
<td><strong>Repetitions completed for MMCIR (reps)</strong></td>
<td>469 (104)</td>
<td>389* (43)</td>
<td>438 (106)</td>
</tr>
</tbody>
</table>

Mean (sd). *$p < 0.05$ vs. EXP within each session. MMCIR – multimodal circuit training session, EXP – experienced group, NOV – novice group. Mod – modified scaling, RR – ring rows.

**Table 3. Rate of perceived exertion across each of the MMCIR and MMHIIT sessions for experienced and novice participants**

<table>
<thead>
<tr>
<th></th>
<th>1 min</th>
<th>5 min</th>
<th>9 min</th>
<th>13 min</th>
<th>17 min</th>
<th>21 min</th>
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<tbody>
<tr>
<td><strong>MMCIR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>11.3 (2.4)</td>
<td>13.7 (1.9)</td>
<td>14.9 (1.7)</td>
<td>15.8 (1.6)</td>
<td>16.6 (1.6)</td>
<td>18.0 (1.5)</td>
</tr>
<tr>
<td>EXP</td>
<td>11.4 (2.1)</td>
<td>13.8 (1.7)</td>
<td>15.0 (1.8)</td>
<td>16.0 (1.7)</td>
<td>16.8 (1.8)</td>
<td>18.1 (1.6)</td>
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<tr>
<td>NOV</td>
<td>11.2 (2.5)</td>
<td>13.6 (2.1)</td>
<td>15.0 (1.7)</td>
<td>15.7 (1.5)</td>
<td>16.5 (1.5)</td>
<td>17.9 (1.4)</td>
</tr>
<tr>
<td><strong>MMHIIT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>13.4 (1.8)</td>
<td>14.3 (1.7)</td>
<td>15.0 (1.7)</td>
<td>15.4 (1.7)</td>
<td>16.2 (1.7)</td>
<td>16.8 (1.8)</td>
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<tr>
<td>EXP</td>
<td>13.9 (1.7)</td>
<td>14.7 (1.7)</td>
<td>15.3 (1.7)</td>
<td>15.7 (1.6)</td>
<td>16.6 (1.4)</td>
<td>17.2 (1.4)</td>
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<tr>
<td>NOV</td>
<td>13.0 (1.9)</td>
<td>14.0 (1.7)</td>
<td>14.8 (1.6)</td>
<td>15.2 (1.8)</td>
<td>15.9 (1.8)</td>
<td>16.5 (2.0)</td>
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</tbody>
</table>

Mean (sd). No significant differences between EXP and NOV for each session or between sessions. MMHIIT – multimodal high-intensity interval training session, MMCIR – multimodal circuit training session, EXP – experienced group, NOV – novice group.
(MMHIIT) and the multimodal high-intensity circuit exercise (MMCIR) methods of training resulted in very high heart rates (averaging 76 and 88% of HR maximum, respectively) and rate of perceived exertion responses (Table 3) across 21 minutes of exercise. It is well recognised that high intensities of continuous or interval, mono-structural exercise training are generally superior to lower intensities for a range of fitness and health benefits. Certainly, the levels of intensity observed during these multimodal sessions are at the higher end of intensities recommended for most apparently healthy adults for the development of cardiovascular fitness and would likely be comparable to mono-structural exercise for this purpose. These high levels of intensity; however, may also predispose more inexperienced participants to a higher risk of injury with more complex movement patterns, or to a higher risk of cardiovascular or metabolic complications during exercise and warrant attention to proper screening, monitoring, progressions, and programming.

The session average HR responses to the MMHIIT were approximately 10 percent of predicted maximum lower than during MMCIR, despite the work during M-HIIT being conducted at an “all-out” effort. This finding is consistent with previous research using mono-structural exercises, which compare HIIT with continuous aerobic exercise. As with mono-structural exercise, one of the advantages of MMHIIT is the potential for similar aerobic, greater anaerobic, and additionally, greater muscular adaptation, with less training volume compared with aerobic exercise. This suggestion, however, requires further study on the long-term training effectiveness of this method of exercise.

The results of this study are similar to previous studies demonstrating that circuit training using resistance exercises elicits a significantly increased heart rate response. Often, circuit training will result in heart rates higher than traditional resistance training using long rest periods. Most studies elicit average heart rates across the entire session in the range of 60 – 80% of predicted maximum or elicit higher heart rates for a shorter period of time; however, we are unaware of other reports of circuit training sessions resulting in heart rates sustained around 89% of predicted maximum for the duration utilised in our study.

Traditional HIIT using mono-structural movements such as running or cycling has been shown to elicit similarly high heart rates as those observed in the present study. Buchheit et al. (2012) found that 6 repetitions of 30 second all-out cycling sprints followed by 2 minute rest intervals elicited an average peak heart rate per interval of 96% of maximum heart rate along with an overall session average of 82% of maximum. Using a protocol of 60 second intervals at peak aerobic power interspersed with 60 seconds of low intensity recovery, Little et al. (2011) found that the heart rate during each work interval averaged 88%, a similar finding to the present study. These findings are in contrast to previous suggestions that resistance-based training cannot match the intensities attained using modalities such as running or cycling.

An advantage that multimodal, resistance-based training has over mono-structural exercise training is the potential for eliciting both strength and endurance gains. Strength training alone usually does not result in endurance or aerobic adaptations; whereas endurance training does not usually result in gains in muscle strength or size. Traditional programs that are designed to improve both endurance and muscle strength or size usually need to have concurrent strength and endurance components. These programs run the risk of developing an interference effect; whereby the strength or hypertrophy gains are blunted compared to training for these qualities alone. These risks are typically reduced with the use of higher intensity rather than higher volume endurance exercise; however, the strength and endurance components are usually combined such that the overall training volume is increased. Incorporating HIIT using resistance training methodology may result in simultaneous endurance and strength adaptions with less volume; however this suggestion requires further research.
The secondary objective of this study was to examine the differences in the responses to each type of exercise between experienced and novice participants. In the MMCIR session, the experienced group exhibited a significantly higher heart rate response throughout the session, despite a similar RPE. In the MMHIIT session, there was a main effect for a higher heart rate in the experienced group; however, this difference between groups was more evident during recovery from the high-intensity intervals than during the intervals themselves. The novice participants were able to achieve very similar peak heart rate responses as compared with the experienced group. These findings together suggest that, as expected, the experienced exercisers were able to tolerate higher relative workloads than participants in the novice group, despite similar perceived exertion. Although not specifically measured in this study, this finding is likely an indication of a higher overall fitness level in the experienced group.

There are a few limitations of this study. First, there was no attempt to stratify or measure the level of fitness of the participants in either the experienced or novice group. It is possible that differences in fitness level alone, and not experience, would result in the differences reported. Second, it should be noted that the novice participants in this study were not true beginner trainees as they had undergone a significant amount of instruction, preparation, and practice with CrossFit training prior to the study. The results of this study may not be generalisable to those novices who have not undergone this initial training. Third, absolute workloads were not measured to confirm that experienced practitioners were completing each session at a higher workrate than the novice practitioners; however, this can be reasonably assumed because of the greater loads used and repetitions performed by the experienced group. Future research should further examine different types of CrossFit training methods using more comprehensive measures. Prospective, controlled trials are required to determine the long term effectiveness and safety of this type of training.

CONCLUSIONS

The results of this study demonstrate that both continuous circuit and high-intensity interval CrossFit sessions using multimodal, resistance-based movement patterns can be used to elicit a significant heart rate response during exercise and are likely appropriate training methods for achieving recommended target intensities for both novice exercisers and experienced athletes. Experienced athletes demonstrated evidence of increased workloads and greater ability to sustain higher heart rates than the novice practitioners, suggesting greater work capacity.

PRACTICAL APPLICATION

CrossFit is a relatively new, world-wide phenomenon with over 11,000 affiliate facilities and over 200,000 athletes participating in the 2014 CrossFit Open. In addition to the competitive aspects of CrossFit, there are countless additional non-competitive participants who use CrossFit training as a method of attaining the recommended dose of physical activity and exercise needed for health and fitness. The methodology of training using CrossFit exercise has not yet been studied extensively. The results of this study demonstrate that, in CrossFit trainees, both continuous and HIIT CrossFit workout sessions using multimodal, resistance-based movement patterns can be used to elicit a significant cardiovascular response during exercise and are likely appropriate training methods for achieving recommended target intensities for both novice exercisers and experienced athletes.

In addition, more experienced athletes likely have greater work capacity as demonstrated by their ability to achieve increased training workloads and to sustain higher heart rates than the novice practitioners.
REFERENCES


