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ENERGY EXPENDITURE AND RELATIVE EXERCISE INTENSITY ON THE FREEBOUNDER^{TM}

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ENERGY EXPENDITURE AND RELATIVE EXERCISE INTENSITY ON THE FREEBOUNDER™

By Jared Hartung

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree of Masters of Science in Clinical Exercise Physiology.

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ABSTRACT

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Regular physical activity provides many health benefits. However, the principle excuse for a sedentary lifestyle is lack of time. In this regard, more time-effective protocols have been used. One such protocol is high-intensity interval training (HIIT). HIIT has been shown to provide the benefits of moderate-intensity continuous exercise (MICE) with significantly less volume and duration. However, one downfall to many HIIT protocols is the increased impact forces. The Freebounder™ is a low-impact alternative. The goal of this study was to examine the intensity of exercise on the Freebounder™ and see if it meets ACSM's recommendations for improving cardiorespiratory fitness and body composition. Fourteen healthy, college-aged individuals completed a 12-minute training session on the Freebounder™. Heart rate (HR), VO_2, and Rating of Perceived Exertion (RPE) were recorded. The average %HRmax was 75.0% $\pm$ 12.74%. The average %VO_2max was 48.0 $\pm$ 4.54%. The average RPE was 12.3 $\pm$ 1.35. Based on the results, a training session falls into the moderate to intense category of intensity as described by ACSM. In this regard, it appears that exercising on the Freebounder™ will increase cardiorespiratory fitness.

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INTRODUCTION

Physical inactivity is currently recognized as the fourth leading risk factor for global mortality (World Health Organization 2018). A sedentary lifestyle has been shown to have many consequences, including increased risk for cardiovascular disease, metabolic disease, and some cancers (Center for Disease Control and Prevention 2015). As little as 20 minutes of exercise per day has been shown to significantly reduce the risk of a sedentary lifestyle (American College of Sports Medicine 2018). However, the chief excuse for a lack of physical activity is insufficient time (Trost, Owen, Bauman, Sallis, and Brown 2002; Gibala & Shulgan 2017).

High-intensity interval training (HIIT) has been shown to cause similar, if not better, aerobic improvements compared to moderate-intensity continuous exercise (MICE), with a significantly lesser time commitment (Gillen & Gibala 2014). Burgomaster et al. (2008) showed that a HIIT protocol caused similar improvements in VO_2max and cardiovascular and skeletal muscle remodeling with 10-fold less volume and a significantly lower time commitment than the MICE group.

Unfortunately, HIIT also has its downfalls. HIIT may not be suitable for certain groups of individuals, including those with chronic musculoskeletal conditions, such as osteoarthritis (OA). This is because HIIT protocols have been shown to have higher impact forces than MICE (Triplett et al. 2009). These high impact forces can aggravate existing OA, or with repetitive use, potentially cause new or worsened OA or other musculoskeletal issues. In this regard, more low impact modalities have been sought for HIIT training.

One such modality is the Freebounder™ (John Louis, Northfield, IL), invented by John Louis. In order to receive the benefits of moderate to high intensity aerobic training with the impact forces of low intensity training. The Freebounder™ is a spring-loaded platform and frame that incorporates upper and lower body movements to provide a total body aerobic workout (Figure 1). Although there is no published research on the Freebounder™, there have been numerous studies published on the physiological effects of trampoline exercise, a similar mode of exercise.

Figure 1. Image of the Freebounder™

Trampolines were first used to train spatial awareness and balance in US Air Force pilots. From there they were slowly integrated into training programs for specific sports and athletes until eventually rebounding became its own sport (Esposito & Esposito, 2009). Rebounding has been widely researched and compared to other exercise modalities. McGlone, Kravitz, and Janot (2002) demonstrated that heart rate (HR) and VO_2 were unchanged compared to running on a treadmill when exercising at prescribed

Ratings of Perceived Exertions (RPE). Furthermore, Perantoni, Deresz, Lauria, Lima, and Novaes (2009) analyzed choreographed rebounding sessions and demonstrated that they provoked an 81% HRmax and 64% VO_2max response with a 135 bpm cadence, illustrating that rebounding can be an intense form of exercise by ACSM's standards.

Even though several studies found that trampoline exercise provides the same cardiorespiratory effects as running, other studies have found conflicting results. Gerberich et al. (1990) found that HR and VO_2 were significantly lower while jumping on a trampoline compared to running, especially at higher exercise intensities. Similarly, Weston, Khan, and Mars (2001) found the VO_2 response when running was significantly greater than when exercising on a mini-trampoline at any given HR.

Most studies done on a mini-trampoline do not involve the upper body, but the Freebounder™ incorporates both the upper and lower body to achieve a full body aerobic workout. Thus, the current study was designed to examine the intensity of completing HIIT on the Freebounder™ and determine if it meets ACSM's guidelines for improving cardiorespiratory fitness and body composition.

METHODS

Subjects

The subjects for this study were 14 healthy, college-aged volunteers recruited from the University of Wisconsin - La Crosse campus. The subjects were recreationally active, exercising at least 3 times per week. Each subject completed the PAR-Q to screen for cardiovascular and orthopedic contraindications to exercise and provided written informed consent prior to participating in this study. The study was approved by the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects.

Procedures

Initially, each subject completed an incremental maximal exercise test on a treadmill. Subjects ran at a self-selected pace, which was kept constant throughout the test. The incline began at 0% grade and increased 2.5% every 2 minutes until the subject reached volitional exhaustion. During the test, HR was monitored continuously and recorded every minute using radiotelemetry (Polar Inc., Bethpage, NY) HR monitor. VO_2 was measured continuously and recorded every minute using an AEI (AEI Technologies Inc., Pittsburgh, PA) metabolic cart. RPE was recorded at the end of each 2-minute stage and at maximal exertion using the 6-20 Borg Scale (Borg, 1998).

Following completion of the treadmill test, subjects completed 1-2 practice trials on the Freebounder™, followed by a 12-minute DVD-based workout in order to become familiar with the exercise movements to be performed. Once proficient at the routine and movements, subjects completed an exercise session on the Freebounder™, following the same 12-minute DVD used during practice. Individual subject pace was as intense as possible. The specific exercises and the order of exercises included in the workout were based on pilot studies and are presented in Appendix A. In general, exercises that used larger muscle groups were 30 seconds in duration whereas exercises using smaller muscle groups were 15 seconds in duration. This was based on general interval training principles (Gillen & Shulgan 2017). Throughout this session, HR and VO_2 were monitored continuously and recorded every 30 seconds, while RPE was recorded every 2 minutes using the 6-20 Borg Scale.

RESULTS

Descriptive characteristics of the 14 subjects who participated in the study are presented in Table 1. Responses during the 12-minute Freebounder™ workout are presented in Table 2 and Figures 2-6, respectively.

Table 1. Descriptive characteristics of subjects.

	Males (n=9)	Females (n=5)
Age (yrs)	22.8 ± 1.30	22.4 ± 2.07
Height (cm)	181.9 ± 6.40	169.4 ± 8.59
Weight (kg)	82.7 ± 8.30	63.1 ± 11.56
VO_2max (ml/kg/min)	55.4 ± 7.32	42.9 ± 4.21
HRmax (bpm)	187.0 ± 10.99	189.8 ± 2.68

Values represent mean ± standard deviation.

Table 2. Physiological responses during the Freebounder™ exercise session.

	Males (n=9)	Females (n=5)	Overall (N=14)
Peak VO_2 (ml/kg/min)	34.2 ± 5.28	26.8 ± 1.68	31.5 ± 5.62
Average VO_2 (ml/kg/min)	26.2 ± 3.78	20.8 ± 2.84	24.3 ± 4.02
Average % VO_2max	47.5 ± 5.00	48.8 ± 3.92	48.0 ± 4.54
Peak HR (bpm)	160.6 ± 22.33	168.4 ± 13.79	163.4 ± 19.51
Average HR (bpm)	135.1 ± 30.81	148.8 ± 12.27	140.0 ± 26.01
Average % HRmax	72.2 ± 15.38	79.3 ± 3.77	75.0 ± 12.74
Kcal/min	10.9 ± 1.57	6.6 ± 0.90	9.2 ± 2.67
RPE average	12.5 ± 1.59	12.0 ± 0.83	12.3 ± 1.35

Values represent mean ± standard deviation.

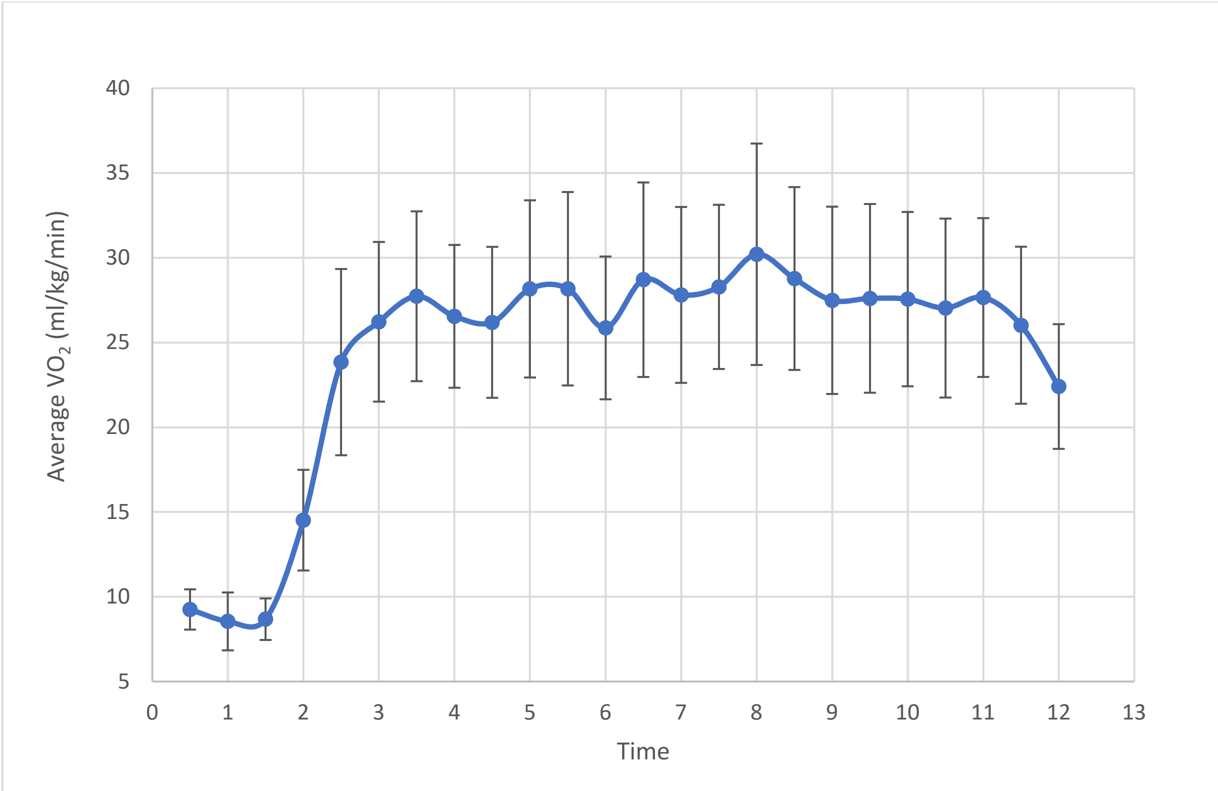

Figure 2. Average VO_2 during the Freebounder™ exercise session.

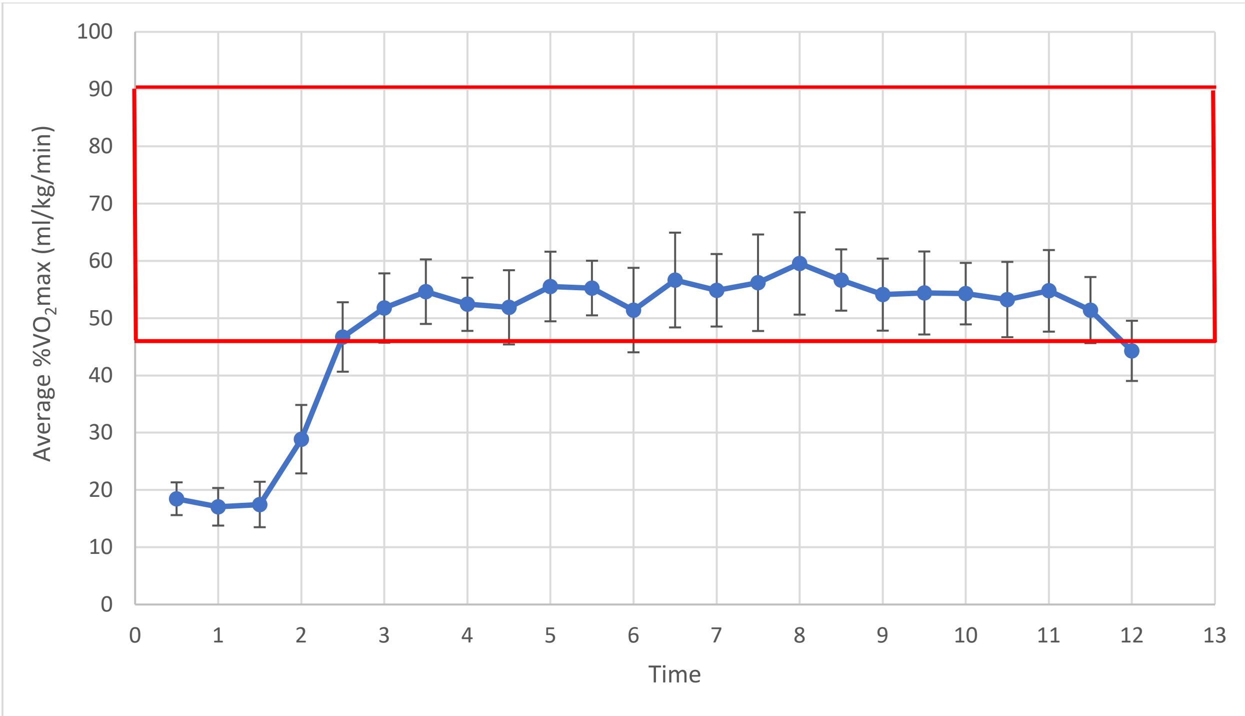

Figure 3. Average %VO_2max during the Freebounder™ exercise session. The boxed area corresponds to ACSM guidelines for improving cardiorespiratory endurance.

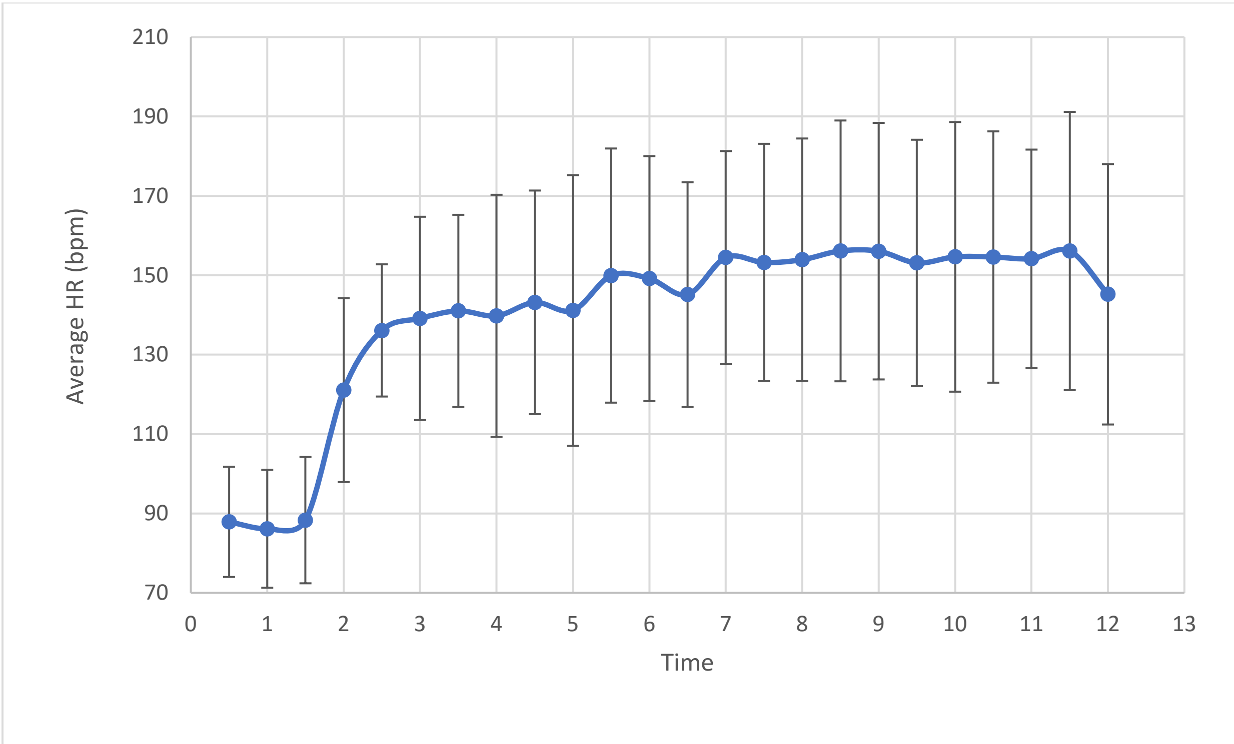

Figure 4. Average HR during the Freebounder™ exercise session.

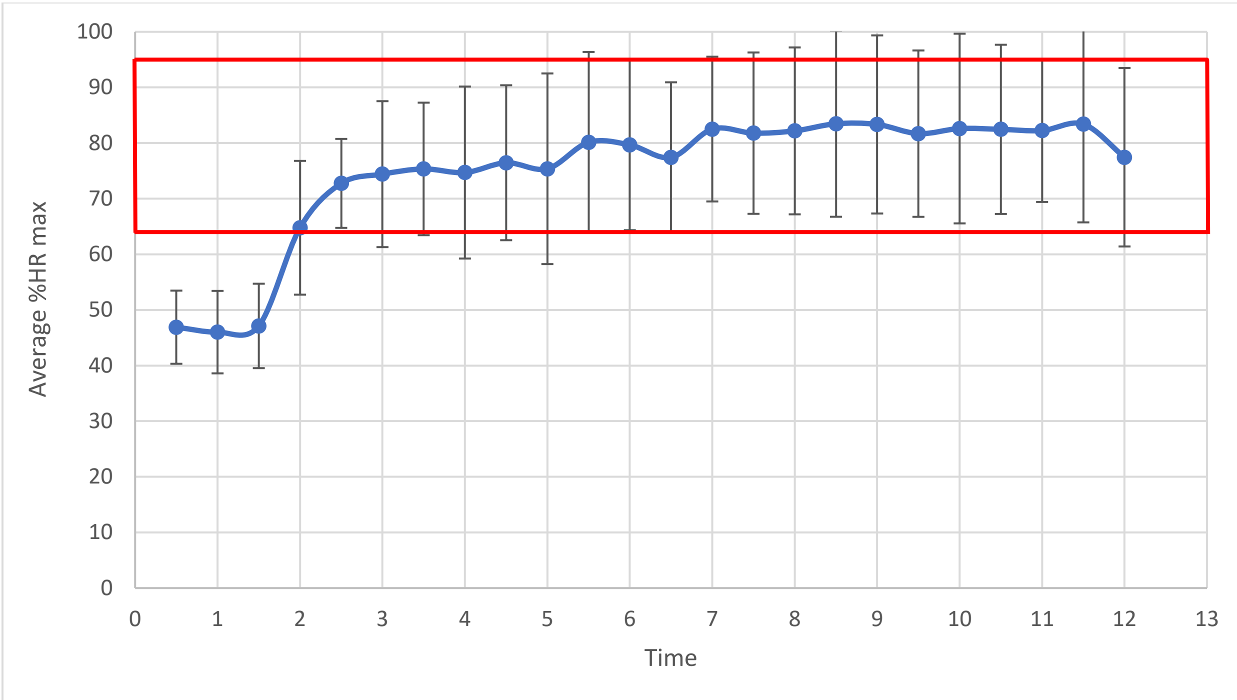

Figure 5. Average %HRmax during the Freebounder™ exercise session. The boxed area corresponds to ACSM guidelines for improving cardiorespiratory endurance.

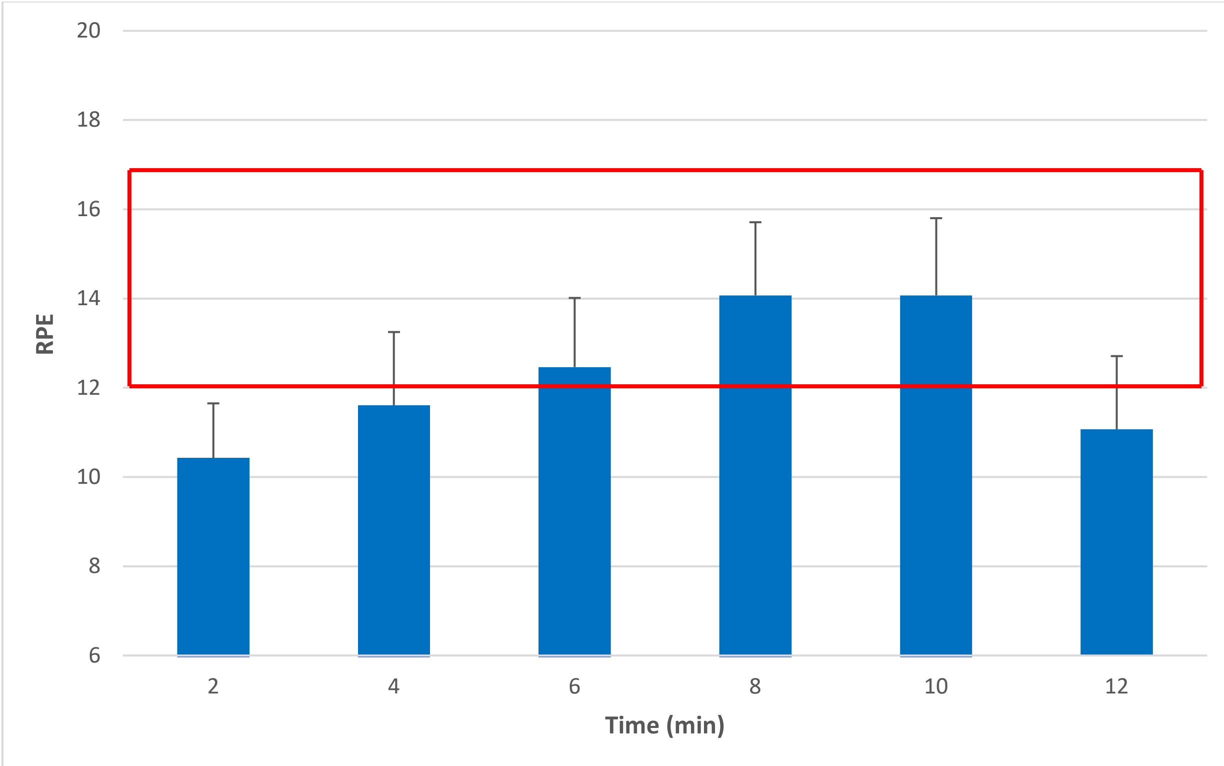

Figure 6. Average RPE during the Freebounder™ exercise session.

DISCUSSION

The purpose of this study was to examine the relative exercise intensity and energy expenditure while completing a HIIT training session on the Freebounder™ and determine if it met ACSM's guidelines for improving cardiorespiratory fitness and body composition. To achieve this goal, ACSM (2018) recommends exercising between 64-95% of HRmax or 46-90% of VO_2max. We found the overall relative exercise intensity of the Freebounder™ exercise session to be 75% of HRmax and 48% of VO_2max, which are within ACSM guidelines for improving cardiorespiratory fitness. Accordingly, their intensities would classify the overall workout on the Freebounder™ as moderate-intensity exercise. Another way to quantify exercise intensity is by using RPE. ACSM (2018) recommends individuals exercise in the range of 12-17 on the 6-20 Borg scale. In the current study, subjects exercised at an average RPE of 12.3, which corresponds to moderate or “somewhat hard” exercise based upon the verbal cues on the Borg scale (Borg, 1998).

The results of the present study are in general agreement with the findings of McGlone et al. (2002) and Burandt et al., (2016). McGlone et al. found that when subjects exercised on a mini-trampoline at the same RPE as running on a treadmill, they averaged 81% of HRmax and 63% of VO_2max. Burandt et al. (2016) found that subjects exercised at an average of 79% of HRmax, 59% of VO_2max, and an RPE of 11.7 when completing a Jumping Fitness mini-trampoline routine. As can be seen, exercising on the Freebounder™ resulted in almost identical relative HR values (%HRmax), but somewhat lower relative VO_2 values (%VO_2max). This would indicate that exercising on the Freebounder™ elicits a pressor response, where HR is elevated disproportionately relative to VO_2. During many of the exercises on the Freebounder™, the user specifically targets the upper body to perform the different movements (e.g., military presses and dips). Because the upper body muscles are smaller than the lower extremities, they require less energy, resulting in a lower relative oxygen cost. Additionally, some of the exercises require gripping the frame of the Freebounder™ (e.g., lateral core glide and alpine ski), which may also result in a pressor response.

Many individuals start exercising or continue to exercise in order to lose or maintain body weight. ACSM recommends individuals expend 240 – 400 Kcals per session (~8 – 13 Kcals/min) in order to meet this goal (Donnelly et al., 2009). In the current study, the average energy expenditure was 9.2 Kcal/min. These intensities are within the range of what would be recommended, although with a targeted duration of 12 minutes the total expenditure would only result in roughly 110 Kcal. Similarly, Burandt et al. (2016) found the average energy expenditure during a 19-minute mini-trampoline fitness workout to be 10.9 Kcals/min.

In conclusion, the current study found the relative exercise intensity of the Freebounder™ exercise session to be 75% of HRmax and 48% of VO_2max. Additionally, subjects expended an average of 9.2 Kcal/min. Collectively, this data suggests that exercising on the Freebounder™ would be considered “moderate-intensity” exercise and should result in significant improvements in aerobic capacity and body composition if the product is used regularly. However, based on an intentionally short duration, the total energy expenditure may be too low to adequately contribute to improvement in body composition.

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APPENDIX A

12-MINUTE FREEBOUNDER^{TM} WORKOUT

1. Active Recovery 90 s
2. Squat 30 s
3. Alpine Ski 15 s
4. Burst 30 s
5. Lateral Core Glide 15 s
6. Squat 30 s
7. Active Recovery 15 s
8. Burst 30 s
9. Dip/Row 15 s
10. Squat 30 s
11. Military Press 15 s
12. Burst 30 s
13. Active Recovery 15 s
14. Squat 30 s
15. Lateral Core Glide 15 s
16. Burst 30 s
17. Crunch 15 s
18. Squat 30 s
19. Military Press 15 s
20. Burst 30 s
21. Dip/Row 15 s
22. Squat 30 s
23. Active Recovery 15 s
24. Burst 30 s
25. Lateral Core Glide 15 s
26. Squat 30 s
27. Active Recovery 60 s

APPENDIX B

REVIEW OF LITERATURE

Introduction

The diverse and comprehensive health benefits of exercise have been well documented. Exercise has been shown to decrease risk of cardiovascular disease, metabolic disease, and some cancers. Additionally, it can help to regulate a healthy body weight (BW), strengthen the musculoskeletal system, improve mental health, decrease mortality, and improve quality of life (Center for Disease Control and Prevention 2015; American Heart Association 2014; & World Health Organization 2018). Currently, the American College of Sports Medicine (2018) recommendation for exercise is at least 150 minutes of moderate intensity (64%-76% HRmax or 46%-63% VO_2max) exercise per week or 75 minutes of vigorous intensity (77%-95% HRmax or 64%-90% VO_2max) per week. However, even as little as 20 minutes of exercise per day at a low to moderate intensity has been shown to have health benefits and can drastically decrease the risk of mortality.

Interval Training and its Benefits

With such minimal time requirements needed in order to observe significant health benefits, it is shocking that physical inactivity is still recognized as the fourth leading risk factor for global mortality (World Health Organization 2018). The most common justification for physical inactivity is the time commitment (Trost, Owen, Bauman, Sallis, and Brown 2002; Gibala & Shulgan 2017). In our busy society, many people find it difficult to set aside 30-60 minutes a day for exercise. However, there are many forms of physical activity that can help decrease time demands in order to gain benefits from exercise. High-intensity interval training (HIIT) is a style of exercise that employs bouts of moderate to vigorous activity separated by sessions of low intensity exercise or rest. This style of exercise can help to reduce total session time to <20 minutes and still produce enormous benefits (Gillen & Gibala 2013). HIIT has been shown to be as effective as, or even superior to, moderate intensity continuous exercise (MICE) in improving aerobic capacity, increasing resting metabolic rate (RMR), improving body composition, and up-regulation of skeletal muscles proteins and mitochondrial biomarkers (Gillen and Gibala 2013; Schubert, Palumbo, Seay, Spain, and Clarke 2017). Although impressive, HIIT's time efficiency may be the greatest benefit. For example, a study completed by Burgomaster et al. (2008) showed that a 6-week HIIT protocol caused similar increases in VO_2max and cardiovascular and skeletal muscle remodeling when compared with a more traditional MICE protocol. Moreover, the HIIT protocol required 10-fold less volume than the MICE protocol and the overall time commitment was significantly decreased. Although Burgomaster et al. used a modified Windgate test for their HIIT protocol, whereas other studies have shown that in as little as 40 seconds total work time and less frequent high intensity intervals can produce significant aerobic and anaerobic benefits (Gillen & Gibala 2013; Gillen et al. 2016).

Designing a HIIT Protocol

Beginning a HIIT program may appear overwhelming, especially since it has more components than a standard MICE training program. Work duration, work to rest ratio, working intensity, and resting intensity are just some of the components that have to be planned prior to beginning a HIIT protocol. However, as Gibala (2017) discusses in his book, “The One Minute Workout”, the key ingredient to HIIT’s effectiveness is the intensity level of the working bouts as well as the change in intensity. Gibala is referencing evidence found from the experiment completed by Hazell, MacPherson, Gravelle, and Lemon (2010). In this study, two HIIT protocols were compared, one with 10-second working bouts and one with 30-second bouts. The results showed that the 10-second protocol increased aerobic and anaerobic markers to the same degree as the 30-second protocol. This demonstrated that peak power output (PPO) is the driving force for HIIT’s efficacy, not the work duration. In this regard, we can see that the length of the working bouts is not critical as long as total work capacity and PPO is maintained. However, the length of the sprint bouts does appear to have some minor differences. Islam, Townsend, and Hazell (2017) compared 5-second, 15-second, and 30-second sprint bouts and found that the shorter intervals (5 and 15 seconds) promoted greater energy expenditure (EE) during the workout without compromising postexercise EE. These studies show the effectiveness of HIIT is determined by its high degree of intensity during the working intervals.

The final component of HIIT is the rest intervals. Gillen and Gibala (2014) have discussed that as intensity during the working intervals rises, the length of the rest period, or low intensity period, should be increased, at least long enough for the type II muscles fibers to recover in order to promote optimal power output during the following work interval. It appears that a rule of thumb for these high intensity bouts is a work to rest ratio of 1:8, as previously seen in the literature (Gillen & Gibala 2014).

Downfall of HITT

Although HIIT appears to be both a timesaving exercise protocol and immensely beneficial to overall health; it does have its downfalls. One argument is that HIIT is not an acceptable form of exercise for a previously sedentary population. Hardcastle, Ray, Beale, and Hagger (2013) discuss the psychological downfalls of HIIT, which include an avoidance of HIIT due to the aversive nature, a need for a high level of motivation and competence, low enjoyment due to the intensity of HIIT (although some studies say otherwise), and a need for a high degree of self-regulation as a result of the complex nature of a HIIT prescription. The major premise to adherence of an exercise program is enjoyment and a positive affect elicited from the exercise. Although many studies have shown that the positive affects of HIIT are lower than MICE, some studies have shown that decreasing the length of the exercise bout and increase the number of intervals can help to combat this dilemma (Hardcastle 2013; Townsend et al. 2017).

Furthermore, another potential disadvantage of HIIT is the relatively high impact forces when compared to MICE. Regardless of the modality, HIIT protocols produce higher levels of impact forces than their MICE counterparts, due to the nature of the intensity (Triplett et al. 2009). These higher levels of impact forces have been hypothesized to increase incidence of injury and, with chronic use, increase the rates of osteoarthritis (OA). This is troublesome as OA is a degenerative disease that often takes years to develop. Currently, the incidence of OA is thought to be as high at 80% in adults >65 years old. With an aging population, we may see these rates increase even more (Aaron & Racine 2013). In this regard, it is important that we decrease impact forces while continuing to promote physical activity in order to decrease the likelihood of OA and benefit from the effects of exercise.

Trampolines as an Exercise Modality

One form of low-impact exercise is through the use of trampolines, also known as rebounding. Trampolines were first used as a recreational device back in 1936; however, they quickly became incorporated into sport and specific training. For example, WWII fighter pilots trained on trampolines in order to improve their spatial awareness and balance. As the popularity of trampolines increased they became incorporated into more and more events and training programs until finally they were integrated into the Olympics (Esposito & Esposito, 2009).

Rebounding has been an interest to the fitness community for many reasons. One reason is that it has been shown to have similar aerobic effects as running. Bhattacharya, McCutcheon, Shvartz, and Greenleaf (1978) looked at the effects of EE, HR, and VO_2 of different walking/running speeds and compared them to varying jump heights on a trampoline. It was found that jumping on a trampoline produced similar effects on HR and VO_2 such that the authors proposed that it could be used as an exercise modality in place of running for those that preferred jumping over jogging/running. In addition, McGlone, Kravitz, and Janot (2002) demonstrated that HR and VO_2 were unchanged between a rebounding session and running on a treadmill while subjects exercised at specific ratings of perceived exertion (RPEs). Furthermore, Perantoni, Deresz, Lauria, Lima, and Novaes (2009) analyzed choreographed rebounding sessions on a mini-trampoline in order to determine if it fell within ACSM's guidelines to improve cardiorespiratory fitness. The 10-minute rebounding session was at a cadence of 135 bpm and corresponded to an average HR of 81% max and VO_2 of 64% max, both of which fall within ACSM recommendations for aerobic training. Other studies have looked at specific subpopulations to determine the efficacy of rebounding. Cugusi et al. (2017) looked at HR and EE during a 45-minute rebounding session in overweight women and found that they burned almost 7 calories/min and averaged 72% HRmax indicating that this is a vigorous form of physical activity. In contrast, some studies have shown that rebounding is significantly less effective than running. Gerberich, Leon, McNally, Serfass, and Edin (1990) used sedentary females on a mini-trampoline and analyzed HR and VO_2 while jumping and stepping. Both of these modalities were shown to elicit lower HR and VO_2 responses when compared to treadmill running. Moreover, long-term training studies have looked at the effects of mini-trampoline use. Edin et al. (1990) conducted a 12-week rebounding training program using sedentary females and found no significant changes in BW, body fat percentage (BF%), resting HR, or resting blood pressure. There was an increase in VO_2max of 4.4%, however this is minor when compared to standard aerobic training programs (roughly 20% improvement).

Another reason that rebounding has become a popular exercise modality is the ability of trampoline workouts to elicit an anaerobic response as well as have a resistance training effect. Aalizadeh, Mohammadzadeh, Khazani, and Dadras (2016) gathered adolescent males for a 20-week trampoline training study. Subjects completed a 90-minute workout four times a week. Following the 20-week training period, subjects were shown to have statistically lower BF%, increased calf and thigh girth, a farther long jump, and a higher high jump. This study helped to demonstrate the anaerobic capacity of a rebounding session. On the other hand, Lemos, Simão, Miranda, and Novaes (2007) argued that rebounding workouts would have a negative impact on strength in an acute manner. In their study, subjects completed 3 sets with their 10 reps max on back squat either after a rebounding session or without any previous exercise. It was found that the number of reps of squat completed following the rebounding session was statistically less than the number of reps completed when no exercise was done previous.

Perhaps the final big benefit of rebounding activities is the low-impact nature of the exercise modality. As previously discussed, OA is a growing concern, especially in the elderly population where prevalence rates are exponentially higher than in the middle-aged and young (Aaron & Racine 2013). However, osteoporosis is also of concern. Non-weight bearing activities, many of which are low-impact, promote increased rates of bone loss and worsened osteoporosis (Mezil et al., 2015). However, a study by Mezil et al., demonstrated that HIIT protocols performed on low-impact aerobic machines enhanced bone turnover markers, indicating increased mineralization and bone formation. This is a significant finding for the geriatric population, which has to combat the loss of bone density with the pain of OA.

Freebounder™

Since rebounding has become so popular and has been shown to have many benefits, John Louis developed the Freebounder™ (John Louis, Northfield, IL). The Freebounder™ is an aerobic machine designed in order to receive the benefits of moderate to high intensity aerobic training with the impact forces of low intensity training. The Freebounder^{TM} is a spring-loaded platform and frame that incorporates both upper and lower body movements to provide a total body aerobic workout. At this time, there is no published research on the machine. In this regard, the goal of this study was to examine the intensity of completing a HIIT protocol on the Freebounder^{TM} and determine if it meets ACSM's guidelines for improving cardiorespiratory fitness and body composition.

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