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Citation for published version:
Campbell, J & Phillips, S 2020, 'The effects of two weeks self-regulated high-intensity interval training on cardiorespiratory fitness, exercise enjoyment, and intentions to repeat', *Journal of Human Sport and Exercise*. https://doi.org/10.14198/jhse.2021.162.15

Digital Object Identifier (DOI):
10.14198/jhse.2021.162.15

Link:
Link to publication record in Edinburgh Research Explorer

Document Version:
Publisher's PDF, also known as Version of record

Published In:
Journal of Human Sport and Exercise

Original Article

The effects of two weeks low-volume self-regulated high-intensity interval training on cardiorespiratory fitness, exercise enjoyment, and intentions to repeat

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ABSTRACT

This study investigated the effect of low-volume self-regulated high-intensity interval training (SR-HIIT) on cardiorespiratory fitness (CRF), exercise enjoyment, and intentions to repeat. Ten untrained, physically active adults (five males and five females, age: 20.3 ± 0.5 years) undertook a 2-week control period followed by 2-weeks SR-HIIT (6 x 10 min cycle ergometer sessions). Sessions involved alternate bouts at a rating of perceived exertion of 17 (work) and 11 (recovery), with bout durations self-regulated by the participant. Maximal aerobic capacity showed a small increase from post-control (3.14 ± 1.03 $L.min^{-1}$) to post-training (3.45 ± 1.14 $L.min^{-1}$; $\bar{X}_{diff}$ 0.31, 95%CI 0.06 $L.min^{-1}$, $d = 0.28$, 95%CL 0.11, 0.45). First ventilatory threshold showed a large increase from post-control (65.6 ± 2.1% $\dot{V}O_{2max}$) to post-training (68.0 ± 2.4% $\dot{V}O_{2max}$; $\bar{X}_{diff}$ 2.4, 95%CI 1.2%, $d = 0.96$, 95%CL 0.27, 1.62). Post-exercise enjoyment showed small ($\bar{X}_{diff}$ 3.5, 95%CI 8.1 AU, $d = 0.31$) and medium ($\bar{X}_{diff}$ 6.9, 95%CI 6.7 AU, $d = 0.68$) increases from SR-HIIT session 1-3 and 3-6, respectively. There were trivial to medium increases in intention to repeat SR-HIIT once per week ($d = 0.06$ to 0.63) and three times per week ($d = 0.28$ to 0.60). Low-volume SR-HIIT elicits meaningful improvements in CRF, is enjoyable, and facilitates good intentions to repeat, and may be an additional option for implementing HIIT to improve general population health and fitness.

Keywords: Sports Health; Intermittent; Perception; Aerobic.

Cite this article as:
Campbell, J., & Phillips, S.M. (2020). The effects of two weeks low-volume self-regulated high-intensity interval training on cardiorespiratory fitness, exercise enjoyment, and intentions to repeat. *Journal of Human Sport and Exercise*, *in press*. doi:https://doi.org/10.14198/jhse.2021.162.15

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Submitted for publication January 21, 2020
Accepted for publication March 10, 2020
Published *in press* April 23, 2020
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202

doi:10.14198/jhse.2021.162.15

INTRODUCTION

High-intensity interval training (HIIT) can elicit similar or better improvements in cardiorespiratory fitness (CRF) than moderate-intensity continuous exercise but with a smaller time commitment (Batacan, Duncan, Dalbo, Tucker, & Fenning, 2017). Therefore, HIIT is a time efficient strategy for improving health and fitness that may appeal to individuals with limited time to be active (Gillen et al., 2014; Niven, Thow, Holroyd, Turner, & Phillips, 2018). However, HIIT can be very challenging, which has led to debate about its public health value (Biddle & Batterham, 2015). Research investigating perceptual responses to HIIT is developing, but conclusive findings are not yet available (Stork, Banfield, Gibala, & Ginis, 2017). However, dual-mode theory indicates that exercise intensity is an important mediator of the affective response to exercise, with intensity exceeding ventilatory threshold (VT) typically generating less positive affect (Ekkekakis, Parfitt, & Petruzzello, 2011).

Reduced volume HIIT protocols that utilise less training time and/or fewer work bouts than 'standard' HIIT have to some extent addressed the challenging nature of HIIT (Allison et al., 2017; Ruffino et al., 2017). However, lack of consensus on the perceptual responses to reduced volume HIIT (Niven et al., 2018; Stork et al., 2017) and the likely presence of inter-individual factors that influence these responses (Bradley, Niven, & Phillips, 2019) emphasises the need to continue identifying ways to make HIIT a feasible exercise option for as many people as possible.

Health improvements are optimised when exercise intensity is tailored to individual capacity (McPhee, Williams, Degens, & Jones, 2010), which has stimulated work into self-regulation of recovery duration during HIIT (McEwan, Arthur, Phillips, Gibson, & Easton, 2018; Phillips, Thompson, & Oliver, 2014). The concept of self-regulating recovery is important considering the large individual variability in required recovery time between high-intensity exercise bouts (McEwan et al., 2018), which indicates that externally imposed recovery periods may be inappropriate for optimising physical and, perhaps, perceptual responses to HIIT (Ekkekakis et al., 2011). The available evidence suggests that individuals are able to self-regulate recovery in a reliable fashion in order to meet the goals of a HIIT session (Phillips et al., 2014).

Self-regulation research has paid little attention to self-regulation of work in addition to recovery. Parfitt, Rose, and Burgess (2006) reported more positive affect when sedentary males self-selected exercise intensity compared to an externally imposed intensity, despite self-selected intensity being higher. Vazou-Ekkekakis and Ekkekakis (2009) found that participants reported reduced enjoyment following exercise at an externally imposed intensity that was identical to a previously self-selected intensity. Ekkekakis and Petruzzello (1999) found that the negative correlation between exercise intensity and affect, heart rate (HR), and ratings of perceived exertion (RPE) became positive when intensity was self-selected. It appears that giving participants autonomy over selection of exercise intensity positively influences perceptions of the exercise, somewhat independent of the actual elicited intensity. This independence is important, as intensity appears to be the primary mediator of affective responses during externally imposed and self-selected HIIT (Kellogg et al., 2019). However, in the self-selected trial of Kellogg et al. (2019) participants were only able to self-select intensity during work bouts; recovery intensity, and the number and duration of work and recovery bouts were externally fixed. It would be interesting to investigate the efficacy of a fully self-regulated HIIT protocol (SR-HIIT). Such a protocol would give individuals full autonomy over session intensity, potentially augmenting perceptual responses (Ekkekakis et al., 2011), and require less equipment/facilities and fewer personnel to supervise the protocol, which could improve ease of implementation. If SR-HIIT elicits improvements in CRF, it would represent another method of implementing HIIT for improving population health.

This study investigated the effect of two-weeks SR-HIIT on CRF, exercise enjoyment, and intention to repeat in physically active individuals. We hypothesised that SR-HIIT would elicit meaningful improvements in CRF compared with baseline, and that participants would report positive enjoyment and intention to repeat SR-HIIT.

METHODS

Participants

Ten healthy participants (five males, five females; age: 20.3 ± 0.5 years; stature: 172.1 ± 12.1 cm; body mass: 64.7 ± 11.2 kg; baseline $\dot{V}O_{2max}$ 3.06 ± 1.05 $L.min^{-1}$; baseline first ventilatory threshold (VT_1) 65.6 ± 3.0% $\dot{V}O_{2max}$) were recruited and completed the study. Inclusion criteria were age 18-35 years, recreationally physically active (≥ 150 min self-reported habitual physical activity per week) but not training for a sport or competition, and unfamiliar with HIIT. The study was explained to participants, and written informed consent was obtained. The research was approved by a University of Edinburgh, Moray House School of Education Ethics Sub-Committee.

Measures

For incremental exercise testing, $\dot{V}O_{2max}$ was determined as the highest 30 sec average $\dot{V}O_2$. First ventilatory threshold was obtained using analysis software (WinBreak 3.7, Epistemic Mindworks, Ames, IA). Expired gas data from the beginning of the incremental test until test termination was imported in breath-by-breath format. Data was screened for outliers (values < 0.1 $L.min^{-1}$ and > 4 standard deviations above the mean) and to reduce noise (values > 3 times smaller or larger than the mean of their two adjacent points) and then adjusted to 20 sec averages. The VT_1 was determined using the V-slope method described by Beaver, Wasserman, and Whipp (1986). The analysis software automatically detected the breakpoint in the $\dot{V}O_2/\dot{V}CO_2$ relationship, but the user could manually adjust this to confirm accuracy. The VT_1 determined from the V-slope method was confirmed by examining plots of ventilatory equivalents for O_2 ($\dot{V}_E/\dot{V}O_2$) and CO_2 ($\dot{V}_E/\dot{V}CO_2$) against $\dot{V}O_2$. The same researcher determined all VT_1 results, which were subsequently confirmed by a physiologist.

For SR-HIIT sessions 1, 3, and 6 the number of work and recovery bouts, duration and mean power output of these bouts, and percentage of the session spent in work and recovery was determined. Heart rate was recorded throughout the sessions at a frequency of 1 Hz. Post-exercise enjoyment was assessed using the Physical Activity Enjoyment Scale (PACES) and scored out of 126, with higher scores indicating greater enjoyment (Kendzierski & Decarlo, 1991). Intention to repeat SR-HIIT once and three times per week was assessed using a 7-point Likert scale (Jung, Bourne, & Little, 2014). Enjoyment and intention to repeat were measured 5 min after the cool-down following SR-HIIT sessions 1, 3 and 6.

Procedures

The study employed a within-participants design with repeated measures of the dependent variables. Testing took place at baseline, after a 2-week control period, and at the end of the 2-week intervention. Participants were instructed to avoid making any significant lifestyle changes for the duration of the study and to avoid strenuous physical or mental activity, alcohol, and caffeine intake for 24 h before each session. Testing and training took place in a temperature-controlled laboratory (21°C).

Participants undertook a familiarisation session prior to baseline testing, which included a standardised verbal introduction and instructions for use of the Borg 6-20 RPE scale in the context of this study:

"When HIIT begins you should cycle as hard as you need to in order to reach an RPE of 17 ('very hard') and then stay at this level of effort for as long as you wish, after which you should cycle very easily until you reach an RPE of 11 ('light'). As soon as you reach RPE 11, you can either remain at this level until you feel ready to increase again or immediately cycle hard again to reach RPE 17 and then maintain this level for as long as you wish, before again recovering to RPE 11. You will repeat this sequence for the 10 min period. The duration of the effort and recovery periods is dependent on how you feel."

Participants were then familiarised with the cycle ergometer (SRM High Performance Ergometer, Germany) used for the incremental maximal test and SR-HIIT sessions. Participants performed the first 5 min of the 10 min HIIT protocol, as described below.

Baseline testing took place ≥ 48 h before the first SR-HIIT session. Stature and body mass were measured (stature: Seca Model 225, Germany, body mass: Seca Model 799, Germany). Prior to the incremental cycle test participants completed a 5 min warm-up at 60 W (Niven et al., 2018), then rested for 5 min and were fitted with a facemask connected to an online gas analyser (Cortex Metalyzer 3B, Germany). A chest strap (Polar Wearlink, United Kingdom) and watch (Polar FS1, United Kingdom) monitored HR. Participants cycled at 60 W for 2 min after which power output increased by 5 W every 20 sec until volitional exhaustion or until cadence dropped below 60 rev.min^{-1} for > 10 sec (Niven et al., 2018). Verbal encouragement was delivered when the participant showed signs of significant effort or dropped below 60 rev.min^{-1} for > 5 sec. At the end of the test, the facemask was removed and participants cycled for 5 min at 60 W.

For the control period, participants were instructed to continue their habitual routine, and to adhere to the conditions of the study related to dietary or lifestyle changes. Adherence was confirmed at the end of the control period.

Six low-volume SR-HIIT cycling sessions were evenly spread over 2 weeks (3 x 10 min sessions per week, total exercise duration 60 min) (Eskelinen et al., 2016). Before each session, participants were reminded of the instructions given in the familiarisation session. No additional guidance or encouragement was given, and participants were blinded to the computer screen to facilitate self-regulation and a natural adaptation to the protocol.

Following a 5 min warm up at 60 W and a 2 min recovery, participants completed 10 min SR-HIIT. Difficulty was modulated by altering cadence, with 60 rev.min^{-1} generating minimal resistance and 90 rev.min^{-1} high resistance. Participants could apply more force to the pedals while cycling at 90 rev.min^{-1} and while cadence would not increase, resistance would. Participants were informed when 1 min of SR-HIIT remained. A 5 min cool down at 60 W was then completed. Total SR-HIIT duration was 10 min, in line with literature showing that low-volume HIIT carried out over two weeks is beneficial to CRF (Gillen et al., 2014). Target RPE values were chosen to a) potentially elicit sufficient intensity for adaptations in CRF (Garber et al., 2011), b) provide an appropriately large difference between work and recovery intensities, and c) align with limited research investigating RPE-prescribed interval training (Ciolac et al., 2015). Heart rate and power output were measured throughout each session at 1 Hz and per pedal revolution, respectively. Within-participants, sessions were scheduled at the same time of day whenever possible.

Post-control and post-training testing

The incremental maximal test was completed at the end of the two-week control period and at least 48 h following completion of the final SR-HIIT session.

Analysis

Null hypothesis significance testing (NHST) readily yields false conclusions about the existence of an effect and the practical meaning of data; *P* values are also subject to large variation due to sampling variability (Wasserstein, Schirm, & Lazar, 2019). As a result, eminent statistical organisations have recently published extensively on moving away from NHST (Wasserstein & Lazar, 2016). This guidance recommends that researchers do not conclude anything about the practical or scientific importance of data based on statistical significance (Wasserstein et al., 2019). Alongside words of caution about NHST, researchers are recommended to analyse data in a way that provides meaningful information about precision and uncertainty in the data, and the likely population effect based on the data (Calin-Jageman & Cumming, 2019). We take this approach in our analysis.

For VO_{2max} and VT_1, mean difference with 95% confidence interval (95%CI) between the three tests (post-control minus baseline and post-training minus post-control) was calculated. Cohen's *d* effect size (ES) for the mean difference was calculated using the equation:

$$d = \frac{\bar{X}_{TP2} - \bar{X}_{TP1}}{s_{mean}}$$

Where $\bar{X}_{TP2}$ = mean of the second time-point, $\bar{X}_{TP1}$ = mean of the first time-point, and s_{mean} = mean of the standard deviations of the two time-points:

$$s_{mean} = \sqrt{\frac{s_{TP1}^2 + s_{TP2}^2}{2}}$$

The mean standard deviation represents the best estimate of the population standard deviation and is the recommended standardiser for *d* in within-participants designs (Calin-Jageman & Cumming, 2019). For the mean difference ES, 95% confidence limits (95%CL) were estimated using the procedure described by Algina and Keselman (2003). The magnitude of ES was defined as trivial ($d < 0.2$), small ($d \geq 0.2$, < 0.5), medium ($d \geq 0.5$, < 0.8), and large ($d \geq 0.8$) (Cohen, 1992). All SR-HIIT in-training data and post-exercise PACES scores were analysed using the same procedures, with comparisons made between sessions 1-3 and 3-6. Mean session HR was compared using intraclass correlation coefficients and interpreted as poor (ICC < .50), moderate (ICC ≥ .50, < .75), good (ICC ≥ .75, < .90), and excellent (ICC ≥ .90). Intention to repeat was analysed by comparing the difference in medians with bootstrapped 95%CL between sessions 1-3 and 3-6. Effect size was calculated using the equation: $r = z/\sqrt{n}$, where *z* is the value obtained from a Wilcoxon Matched-Pairs test, and *n* is sample size (Ivarsson, Andersen, Johnson, & Lindwall, 2013). This ES was converted to Cohen's *d* using the equation: $d = 2r/\sqrt{(1 - r^2)}$ (Ivarsson et al., 2013).

RESULTS

Power output and HR of a representative participant during a SR-HIIT session is in figure 1. This data confirms achievement of a HIIT stimulus. Performance measures between the SR-HIIT sessions are in table 1. Across sessions, all outcome variables remained stable with trivial to small ES. However, in-session characteristics showed large between-participant variability. In sessions 1, 3, and 6 participants voluntarily employed a mean work: rest ratio of 1:1.3 (range 1/.4 to 1/3.7), 1:1.2 (range 1/.2 to 1/5.3), and 1:1.2 (range 1/.3 to 1/2.6), respectively.

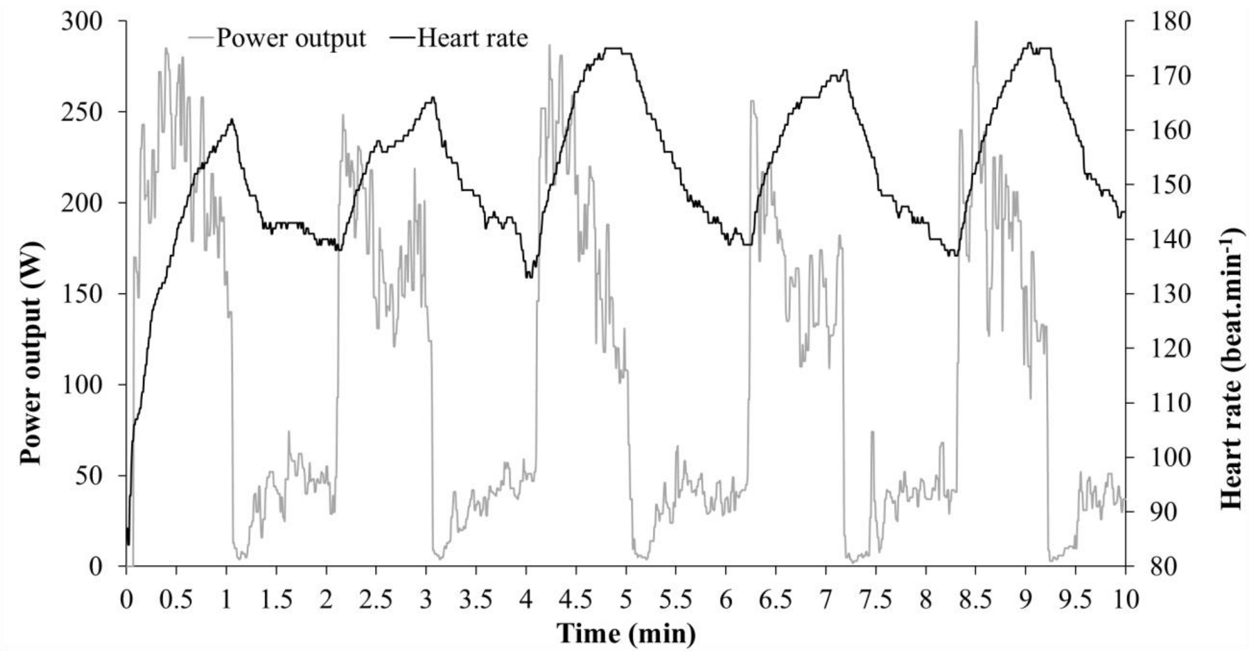
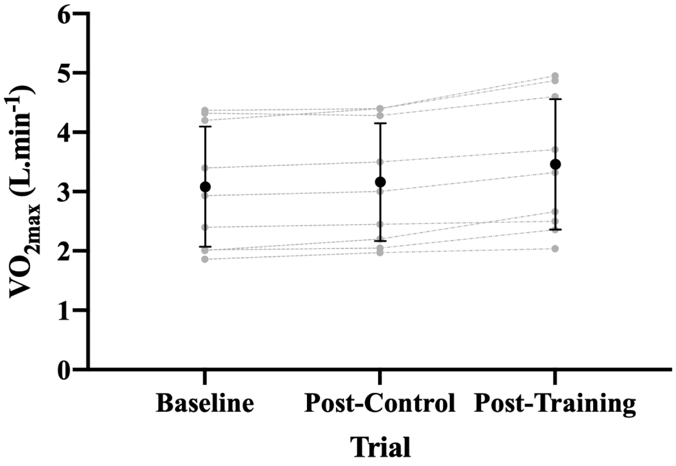


Figure 1. A trace of power output and heart rate from a representative participant during a SR-HIIT session.

Table 1. Comparison of session characteristics for SR-HIIT sessions 1, 3, and 6 (*n* = 10).

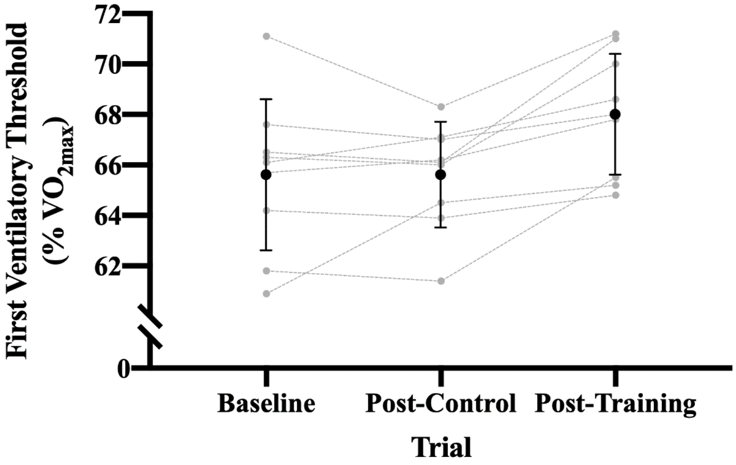
	SR-HIIT 1 Mean ± SD (range)	SR-HIIT3 Mean ± SD (range)	SR-HIIT6 Mean ± SD (range)	1 vs. 3 $\bar{X}_{\text{diff}}$(95%CI) (*d*, 95%CL)	3 vs. 6 $\bar{X}_{\text{diff}}$, 95%CI (*d*, 95%CL)
Work					
Number of bouts	10 ± 4	9 ± 4	9 ± 3	-1.0 (2.0)	0.0 (1.0)
	(5-19)	(4-16)	(6-12)	(-0.21, -0.65 to 0.26)	(0.1, -0.47 to 0.28)
Bout duration (sec)	31.1 ± 18.4	34.7 ± 23.7	34.0 ± 17.4	3.6 (7.8)	-0.7 (12.7)
	(10.9-59.0)	(6.2-79.8)	(8.3-68.9)	(0.15, -0.16 to 0.49)	(0.04, -0.57 to 0.50)
Power (W)	316 ± 138	317 ± 133	307 ± 106	0.9 (34.4)	-10.1 (34.2)
	(181-527)	(141 to 510)	(159-456)	(0.01. 0.21 to 0.23)	-0.08. -0.33 to 0.17)
Session duration (%)	42.8 ± 16.2	44.2 ± 23.3	45.8 ± 21.3	0.7 (5.8)	1.1 (7.7)
	(21.4-73.4)	(15.8-80.5)	(16.7-79.1)	(0.03, 0.23 to 0.30)	(0.05., -0.27 to 0.37)
Recovery					
Number of bouts	10 ± 4	9 ± 4	9 ± 3	-1.0 (2.0)	0.0 (1.6)
	(5-19)	(4-16)	(5-12)	(0.20, -0.15 to 0.44)	(-0.15, -0.59 to 0.28)
Bout duration (sec)	40.5 ± 17.5	41.4 ± 19.0	41.0 ± 21.4	0.9 (7.3)	-0.4 (6.3)
	(12.7-66.9)	(9.0-70.6)	(10.5-77.4)	(0.05, -0.30 to 0.39)	(0.02, -0.29 to 0.25)
Power (W)	41 ± 8	37 ± 14	33 ± 15	-4.3 (6.2)	-3.7 (5.2)
	(27-52)	(8-57)	(6-51)	(-0.35., -0.88 to 0.13)	(-0.23, -0.58 to 0.09)
Session duration (%)	57.2 ± 16.2	55.8 ± 23.3	54.2 ± 21.3	-0.5 (7.4)	-1.4 (9.1)
	(26.6-78.6)	(19.5-84.2)	(20.9-83.3)	(-0.03, -0.36 to 0.31)	(-0.06, -0.44 to 0.32)

Mean HR in SR-HIIT3 (157 ± 14 beat.min^{-1}, 81.6 ± 5.2% HR_{max}) showed a small decrease compared to SR-HIIT1 (164 ± 14 beat.min^{-1}, 85.8 ± 5.8% HR_{max}; $\bar{X}_{diff}$ -7, 95%CI 4 beat.min^{-1}, *d* = -0.48, 95%CL -0.19, -0.85). There was a trivial difference between SR-HIIT3 and SR-HIIT6 (157 ± 15 beat.min^{-1}, 82.1 ± 6.5% HR_{max}, $\bar{X}_{diff}$ 0, 95%CI 3 beat.min^{-1}, *d* = 0.04, 95%CL -0.13, 0.22). Mean HR showed excellent reliability between sessions 1-3 and 3-6 (ICC = .95 and .98, respectively). Peak HR in SR-HIIT3 (175 ± 12 beat.min^{-1}, 91.4 ± 4.6% HR_{max}) showed a small decrease compared to SR-HIIT1 (180 ± 11 beat.min^{-1}, 94.5 ± 4.0% HR_{max}; ; $\bar{X}_{diff}$ -5, 95%CI 3 beat.min^{-1}, *d* = -0.43, 95%CL -0.12, -0.80). There was a trivial difference in peak HR between SR-HIIT3 and SR-HIIT6 (176 ± 9 beat.min^{-1}, 92.9 ± 3.4% HR_{max}; $\bar{X}_{diff}$ 1, 95%CI 4 beat.min^{-1}, *d* = 0.12, 95%CL -0.19, 0.44).



Note. Grey lines are individual participant values.

Figure 2. Mean (± SD) VO_{2max} at each measurement point.

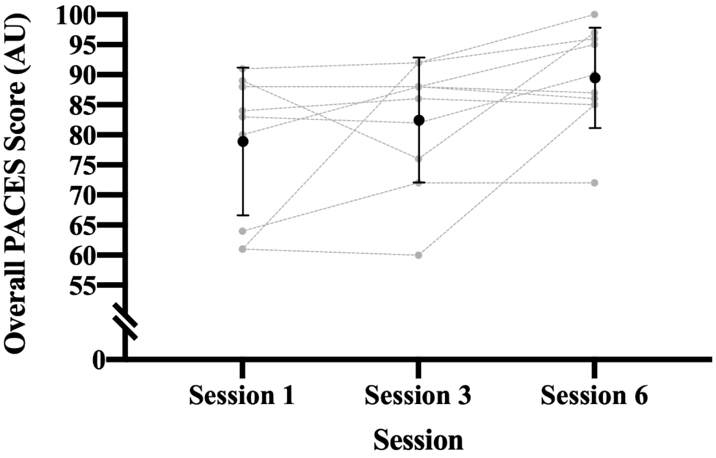


Note. Grey lines are individual participant values.

Figure 3. Mean (± SD) VT_1 at each measurement point.

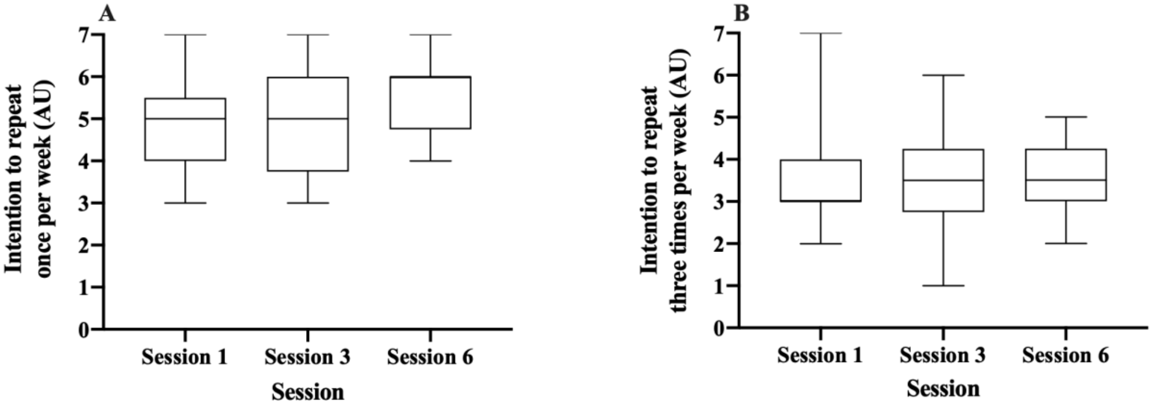
Mean VO_{2max} (figure 2) showed a trivial increase between baseline and post-control ($\bar{X}_{diff}$ 0.08, 95%CI 0.06 $L.min^{-1}$, *d* = 0.08, 95%CL 0.02, 0.14), and a small increase from post-control to post-training ($\bar{X}_{diff}$ 0.31, 95% CI 0.13 $L.min^{-1}$, *d* = 0.28, 95%CL 0.11, 0.45) equivalent to 1.4 METs. First ventilatory threshold (figure 3) was similar at baseline and post-control ($\bar{X}_{diff}$ 0.03, 95%CI 1%, *d* = 0.01, 95%CL -0.41, 0.44) and showed a large increase from post-control to post-training ($\bar{X}_{diff}$ 2.4, 95%CI 1.2%, *d* = 0.96, 95%CL 0.27, 1.62).

Mean PACES score (figure 4) in SR-HIIT3 showed a small increase compared to SR-HIIT1 ($\bar{X}_{diff}$ 3.5, 95%CI 8.1 AU, *d* = 0.31, 95%CL -0.34, 0.94). There was a medium increase in mean PACES score from SR-HIIT3 to SR-HIIT6 ($\bar{X}_{diff}$ 6.9, 95%CI 6.7 AU, *d* = 0.68, 95%CL 0.02, 1.44).



Note. Grey lines are individual participant values.

Figure 4. Mean (± SD) PACES score following SR-HIIE sessions 1, 3, and 6.



Box = 25th percentile, median value, and 75th percentile; bars = minimum and maximum values.

Figure 5. Intention to repeat SR-HIIT once per week (A) and three times per week (B).

Intention to repeat SR-HIIT (figure 5) ≥ once per week showed a trivial change from SR-HIIT1 to SR-HIIT3 (difference in medians = 0.0, 95%CL -0.83, 0.83, *d* = 0.06) and a medium increase between SR-HIIT3 and

SR-HIIT6 (difference in medians 1.0, 95% CL -0.63, 1.63, *d* = 0.72; figure 5a). Intention to repeat SR-HIIT ≥ three times per week showed a medium increase from SR-HIIT1 to SR-HIIT3 (difference in medians = 0.5, 95%CL -0.46, 1.06, *d* = 0.60) and a small difference between SR-HIIT3 and SR-HIIT6 (difference in medians 0.0, 95% CL -1.17, 1.17, *d* = 0.28; figure 5b).

DISCUSSION

Compared to post-control values, two weeks low-volume SR-HIIT led to small and large increases in $\dot{V}O_{2max}$ and VT_1, respectively. Small to medium increases in post-exercise enjoyment and trivial to medium increases in intention to repeat SR-HIIT were observed across the training period.

Two weeks sprint-interval training can increase the $\dot{V}O_{2max}$ of physically active individuals by ~9.5% (Burgomaster, Heigenhauser, & Gibala, 2006; Larsen, Befroy, & Kent-Braun, 2013), and longer duration interventions using submaximal work bouts can improve $\dot{V}O_{2max}$ by ~8.5-14% (Bayati, Farzad, Gharakhanlou, & Agha-Alinejad, 2011; Nybo et al., 2010). These improvements in $\dot{V}O_{2max}$ are similar to the 9.9% (1.4 METs) increase reported in the current study. Improving $\dot{V}O_{2max}$ by one MET reduces mortality risk by 10-25% (Myers et al., 2015). Therefore, SR-HIIT using submaximal work bouts may provide a sufficient stimulus for meaningful increases in CRF. However, the ability of SR-HIIT to increase $\dot{V}O_{2max}$ may depend in part on baseline $\dot{V}O_{2max}$ (Myers et al., 2015). Prior to training, participants in the current study were in the 70th percentile for $\dot{V}O_{2max}$ based on age and gender (American College of Sports Medicine, 2017). Our data suggests that SR-HIIT can be effective in already moderately fit individuals and may potentially be more potent in those with lower baseline fitness.

Two-weeks of SR-HIIT was also sufficient to stimulate a large increase in VT_1. Oxygen consumption at VT_1 is inversely associated with cardiovascular and all-cause mortality risk (Kunutsor et al., 2017), reinforcing the potential for SR-HIIT to meaningfully improve CRF. Participants had baseline VT_1 values towards the upper end of the expected range for untrained adults (Herdy et al., 2016) yet SR-HIIT was able to increase it further, again underlining the apparent potency of our SR-HIIT protocol. An additional benefit of increasing the relative intensity at which VT_1 occurs is that it may allow individuals to exercise at higher relative intensities, and utilise a wider range of exercise protocols, prior to experiencing affective declines associated with exercise > VT.

Mean session HRs met the ACSM criterion for vigorous exercise intensity (Garber et al., 2011). Mean peak HRs also exceeded the ~85-90% HR_{max} shown to improve $\dot{V}O_{2max}$ in healthy active individuals during HIIT (Bacon, Carter, Ogle, & Joyner, 2013). The ability of HIIT to increase aerobic fitness in such a short (session and training) timeframe is linked to rapid increases in mitochondrial density and stroke volume associated with repeated exposure to high exercise intensities (Astorino et al., 2017). Our SR-HIIT protocol elicited a HIIT stimulus (figure 1); therefore, these mechanisms for improved markers of CRF are feasible.

Session characteristics varied substantially between participants, suggesting varying ‘ideals’ in terms of work and recovery characteristics. McEwan et al. (2018) reported large inter-individual variability in recovery duration during self-regulated interval running, attributing this in part to individual differences in afferent cues used to regulate recovery durations. Use of varied afferent cues alongside variability in recovery durations between work bouts supports the contention that externally prescribing a standard recovery duration is inappropriate. Our data extends this work to show large inter-individual variability is also present in the self-selection of work duration and intensity, suggesting that externally imposing these parameters in a HIIT session may also be inappropriate.

Post-exercise enjoyment in the current study was similar to that reported in previous HIIT studies (Hoekstra, Bishop, & Leicht, 2017). However, post-exercise enjoyment of HIIT is variable, with the nature of the HIIT protocol and inter-individual factors likely primary moderators (Bradley et al., 2019; Stork et al., 2017). A benefit of SR-HIIT is that it allows participants to select protocol characteristics that they deem enjoyable. This enjoyment can be derived from two factors associated with autonomy of exercise regulation. Firstly, when given autonomy participants appear to self-select an intensity that will optimise their enjoyment (Ekkekakis et al., 2011). Secondly, autonomy over exercise intensity creates a sense of control, which may improve perceptions of exercise by facilitating a “cognitive reframing” of the exercise (Ekkekakis et al., 2011; Ekkekakis & Petruzzello, 1999; Parfitt et al., 2006; Vazou-Ekkekakis & Ekkekakis, 2009). Participants’ freedom to self-regulate work and recovery, and the associated sense of autonomy, may therefore explain the enjoyment scores in the current study. Coupled with improved CRF, our SR-HIIT protocol appears to be a malleable and efficacious intervention that could facilitate provision of customised exercise options (Ekkekakis et al., 2011).

Participants showed consistently good intention to repeat SR-HIIT once per week compared to three times per week (Figure 5). Basic affect was not measured in the current study, however Rhodes and Kates (Rhodes & Kates, 2015) reported a limited relationship between affect during exercise and intention to repeat. Past experience of exercise, individual differences in tolerance of exercise intensity, and exercise preference may moderate intentions to repeat (Bradley et al., 2019; Rhodes & Kates, 2015). These factors could have contributed to the intention to repeat data in the current study. It is also tempting to suggest that the potentially beneficial influence of autonomy during exercise on affective responses may also have a positive effect on intention to repeat. This is worthy of future research.

The current study recruited participants who were not training for a specific sport or competition but were healthy and recreationally active. Therefore, the results cannot be extrapolated to insufficiently active or clinical populations; this is a fruitful future research direction. The study was not designed to investigate moderators of the perceptual and physiological responses to SR-HIIT. Future research should consider quantifying exercise history and preference, tolerance of exercise intensity, and basic affect to understand better the individual responses to SR-HIIT. Future work could also attempt to unpick how people self-regulate a HIIT session, similar to the approach of McEwan et al. (2018). Together, this may identify “predictor” variables that indicate whether someone is likely to engage positively with SR-HIIT, which could facilitate more targeted exercise prescription.

CONCLUSIONS

We provide novel data to show that two-weeks of low-volume SR-HIIT stimulates meaningful improvements in CRF, is enjoyable, and facilitates good intentions to repeat in a sample of recreationally active participants. SR-HIIT may be a feasible option for implementing HIIT to improve general population CRF.

AUTHOR CONTRIBUTIONS

- Conceptualization: Shaun M Phillips.
- Methodology: Jennifer Campbell, Shaun M Phillips.
- Formal analysis and investigation: Jennifer Campbell, Shaun M Phillips.
- Data collection: Jennifer Campbell.
- Writing - original draft preparation: Jennifer Campbell, Shaun M Phillips.
- Writing - review and editing: Shaun M Phillips.

- Supervision: Shaun M Phillips.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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