Modified sprint interval training protocols. Part II: psychological responses

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<td>Dunn, Emily; Wilfrid Laurier University, Kinesiology and Physical Education</td>
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<td>Hazell, Tom; Wilfrid Laurier University, Kinesiology and Physical Education</td>
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<td>Keyword:</td>
<td>high-intensity interval training, affect, preference, self-efficacy, intentions</td>
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Modified sprint interval training protocols. Part II: psychological responses

Logan K. Townsend, Hashim Islam, Emily Dunn, Mark Eys, Jennifer Robertson-Wilson & Tom J. Hazell

Department of Kinesiology and Physical Education, Faculty of Science, Wilfrid Laurier University, Waterloo, Ontario, CANADA, N2L 3C5

Co-Authors:
Logan K. Townsend
519-884-1970 x4919, ltownsen@uoguelph.ca

Hashim Islam
613-533-6000 x74699, 16mhi@queensu.ca

Emily Dunn
519-884-0710 x 3928, dunn2040@mylaurier.ca

Mark Eys
519-884-0710 x4157, meys@wlu.ca

Jennifer Robertson-Wilson
519-884-0710 x 3928, jrobertsonwilson@wlu.ca

Communicating Author:
Tom J. Hazell, PhD
Department of Kinesiology and Physical Education
Wilfrid Laurier University
75 University Ave W
Waterloo, Ontario, CANADA, N2L 3C5
Email: thazell@wlu.ca
Tel: 519-884-1970 x3048
ABSTRACT

Sprint-interval training (SIT) is a viable method to improve health and fitness. However, researchers have questioned the utility of SIT due to its strenuous nature. The current study aimed to determine if manipulating the sprint and recovery duration, while maintaining the 1:8 work to rest ratio, could uncover a more favourable SIT protocol. Nine healthy active males (23.3±3.0 y, 22.4±2.2 kg·m⁻², 48.9±5.3 mL·kg⁻¹·min⁻¹) participated in three experimental running SIT sessions: (1) 30:240 (4 x 30 sec efforts, 240 sec recovery); (2) 15:120 (8 x 15 sec efforts, 120 sec recovery); (3) 5:40 (24 x 5 sec efforts, 40 sec recovery); and (4) a final behavioural choice follow-up session. Affect, intentions, task self-efficacy, enjoyment, and preference were evaluated. Midway through exercise, affect became more positive for 5:40 compared to 30:240 (p < 0.05) and post-exercise affect was greater for both 5:40 (p = 0.014) and 15:120 (p = 0.015) compared to 30:240. Participants expressed greater intentions to perform 5:40 three and five times/week compared to 15:120 and 30:240 (p < 0.05). Participants felt more confident in their ability to perform 5:40 (p = 0.001) and 15:120 (p = 0.008) compared to 30:240. The 5:40 session was also rated as more enjoyable than 15:120 (p = 0.025) and 30:240 (p = 0.026). All participants preferred the 5:40 protocol. These data suggest that shorter sprints with more repetitions are perceived as more enjoyable and lead to greater intentions to engage in SIT.

Keywords: high-intensity interval training; affect; preference; self-efficacy; intentions
INTRODUCTION

Regular physical activity (PA) has a well-established role in health (Pedersen and Saltin 2006) and accumulating evidence demonstrates that physical inactivity is linked to many chronic diseases (Booth et al. 2012). Despite this information, the majority of people in developed nations still fail to achieve adequate PA (Kohl et al. 2012). Moreover, most exercise interventions are largely ineffective as many adults abandon exercise programs within a few months (Dishman 2001). The reason for this general lack of PA is complex, but the most commonly cited barrier to PA is a perceived lack of time (Trost et al. 2002). Given this, there have been many attempts to determine the minimal amount of exercise necessary to produce positive health benefits (Hazell et al. 2010; Metcalfe et al. 2011; Zelt et al. 2014; Gillen et al. 2014).

High-intensity interval training (HIIT) involves repeated short exercise bouts at near maximal intensities (~90% VO$_{2\text{max}}$) separated by periods of recovery, and has received great attention as a potentially time-efficient approach to improve health and fitness (Gillen and Gibala 2014). Sprint interval training (SIT) is a form of HIIT that typically consists of repeated 30 s “all-out” efforts (>100% VO$_{2\text{max}}$) separated by ~4 min of recovery (Weston et al. 2014). Thus, compared to HIIT, SIT involves shorter bouts of effort, but of far greater intensity, separated by longer rest intervals. SIT consistently improves health and fitness to an equal or greater degree than moderate-intensity continuous training (MICT) in a fraction of the time (Burgomaster et al. 2008; Gillen and Gibala 2014).

However, due to SIT’s strenuous nature, concerns have been raised regarding its tolerability for the general public (Hardcastle et al. 2014; Biddle and Batterham 2015; Del Vecchio et al. 2015; Jung et al. 2016; Astorino and Thum 2016). Researchers have argued that SIT is not actually time-efficient because typical SIT sessions are ~30 min once warm-up and...
cool-down periods are taken into account (Hardcastle et al. 2014). Another concern is that SIT may be perceived as too difficult, and a sedentary population is unlikely to feel sufficiently confident to engage in such a demanding exercise protocol (Biddle and Batterham 2015). Similarly, SIT is argued to be too complex and require such a high degree of self-regulation that placing the onus on an inexperienced exerciser to select the appropriate exercise intensity and duration may be problematic (Hardcastle et al. 2014). Finally, and perhaps most importantly to the current investigation, it has been proposed that SIT will evoke negative affective responses during exercise, ultimately causing rapid attrition and future exercise avoidance (Hardcastle et al. 2014; Biddle and Batterham 2015).

Affective and cognitive variables are important correlates of PA (Bauman et al. 2012). For instance, self-efficacy is consistently the most reliable and strongest predictor of PA involvement (Trost et al. 2002; Bauman et al. 2012) and positive affective responses to exercise are important for future PA participation (Rhodes et al. 2010). Indeed, a small increase in the acute affective response to exercise was associated with an additional 38 min of moderate-intensity exercise/wk at 6 and 12 month follow-up in sedentary individuals (Williams et al. 2008). Given this, understanding how SIT is perceived from a psychological perspective will provide a more comprehensive representation of SIT’s potential to improve health and fitness in the general population.

When considering the role of psychological perceptions (such as affect and enjoyment) in HIIT and SIT as types of PA, results to date have been equivocal (Oliveira et al. 2013; Kilpatrick and Greeley 2014; Kilpatrick et al. 2015b; Saanijoki et al. 2015), though some reports demonstrate greater enjoyment of HIIT compared to MICT in overweight and healthy individuals (Bartlett et al. 2011; Crisp et al. 2012). Interestingly, direct comparison between SIT
(8 x 30 s at 130% work max separated by 90 s recovery, ~79% age predicted max heart rate) and HIIT (8 x 60 s at 85% work max with 1 min recovery, ~77% age predicted max heart rate) in young active individuals found that the affective responses were similar despite greater blood lactate concentrations and perceived exertion during SIT (Wood et al. 2016). Another recent study performed an in-depth exploration of the tolerability and affective responses of HIIT (10 x 1-min bouts at 100% of work peak separated by 1-min rest, ~90% max heart rate) compared to MICT (40% work peak, ~70% max heart rate) and vigorous-intensity continuous exercise (~80% work peak, ~90% max heart rate) in lean but inactive participants (Jung et al. 2014). Affective responses were measured before, during, immediately post-exercise, and 20 min post-exercise along with task self-efficacy, intentions, enjoyment, and preference (Jung et al. 2014). Participants reported greater enjoyment of HIIT compared to MICT and vigorous-intensity continuous exercise, with over 50% of participants preferring HIIT. Moreover, HIIT was perceived as more pleasurable than vigorous-intensity continuous exercise and participants felt equally confident in performing HIIT as MICT (Jung et al. 2014).

Currently little work has explored the perceptions of SIT and, as a result, debate remains regarding the enjoyment and tolerability of SIT. Additionally, the few studies on the psychological aspects of SIT have been limited in the constructs assessed (e.g., perceived exertion (Kilpatrick et al. 2015b)). Another SIT study only assessed traditional (30 s) or longer sprint bouts (60 s) in young healthy participants (Kilpatrick and Greeley 2014), although the practicality is questionable considering traditional 30 s SIT is already highly demanding. Moreover, many SIT protocols have shown promising physiological results from very brief (8-15 s) sprint interval durations (Trapp et al. 2008; Hazell et al. 2010) and minimal (10-20 min/session) total time commitments (Metcalf et al. 2011; Gillen et al. 2014). These reports
suggest that it is the generation of peak power, rather than its attempted maintenance, that drives the physiological responses to SIT (Hazell et al. 2010).

Together with the idea that the prolonged maintenance of power output drives the negative psychological perceptions of HIIT/SIT (Kilpatrick and Greeley 2014; Kilpatrick et al. 2015b), the current study aimed to determine if manipulating the sprint and recovery duration, while maintaining the traditional 1:8 work to rest ratio, could yield more favourable perceptions of SIT. Considering the countless possible variations of SIT protocols and the lack of research into their psychological perceptions, it is valuable to perform an in-depth evaluation of SIT before attempting to make comparisons to other protocols (e.g. MICT and HIIT). In this way it might be possible to characterize the factors capable of producing less offensive SIT protocols. Therefore, this study provides an evaluation of affect, self-efficacy, intentions, enjoyment, and preference in active healthy males during and following three experimental SIT protocols; specifically, (1) traditional 4 x 30 s bouts with 240 s rest; (2) 8 x 15 s bouts with 120 s rest; (3) 24 x 5 s bouts with 40 s rest. A fourth experimental session served to determine participants’ preference where they were asked to indicate the protocol they would prefer to perform again (i.e., a behavioural choice, though after selecting they were not required to perform the exercise). In our companion paper (Islam et al. accepted) we report greater energy expenditure during shortened SIT bouts. In the present paper, we hypothesized that shorter intervals would elicit more positive affective responses and be evaluated more positively than the traditional SIT paradigm. These results will provide important information regarding how to appropriately implement an effective SIT program.
METHODS

Participants

Nine healthy, recreationally active male volunteers (23.3±3.0 y, 178.4±5.4 cm, 78.3±9.0 kg, 22.4±2.2 kg·m⁻², 48.9±5.3 ml·kg⁻¹·min⁻¹) agreed to participate in 3 experimental sessions; participants were blinded to the specific goals of the current project. All participants also participated in a fourth session that served as a behavioural choice follow-up session. The relatively small sample size reflects that data collection was in conjunction with our physiological companion paper (Islam et al. accepted). Participants were non-smokers, recreationally active (≤ 3 sessions/week), not currently engaged in an exercise-training program at the time of data collection (or for 4 months prior), and used no dietary supplements. Participants were instructed to refrain from PA and alcohol for 48 h before all sessions and also to abstain from caffeine the morning of a session. All exercise sessions were the same duration (18 min), separated by >1 wk, and matched for total exercise duration (2 min) and recovery (16 min) by maintaining the same work:rest ratio (1:8 s) to allow for comparison to past SIT work.

Screening and Familiarization

After receiving institutional Research Ethics Board approval, all participants visited the laboratory to complete informed written consent and the Physical Activity Readiness Questionnaire (PAR-Q). Also, at least five days prior to the first data collection, each participant visited the laboratory to become familiarized with laboratory procedures and experimental sessions. This included gathering baseline height and weight, familiarization with questionnaire instruments, and practice using the self-propelled treadmill on which all training would occur (HiTrainer, QC, Canada). Prior to beginning the experimental sessions all participants
performed a graded exercise test to determine maximal oxygen consumption (Islam et al. accepted).

At least one week after completion of the VO_{2max} test, participants completed a counterbalanced randomized three-way crossover study. All participants performed (1) 30:240 (traditional SIT, 4 x 30 s bouts with 240 s rest [4 min]); (2) 15:120 (8 x 15 s bouts with 120 s rest [2 min]); (3) 5:40 (24 x 5 s bouts with 40 s rest). All exercise began with a 7 min warm-up (at ~4.8 km/h) followed by an 18 min SIT session and 5 min cool-down (for a total session duration of 30 min). Warm-up and cool-down were performed on a motorized treadmill (Woodway, WI, USA) for speed consistency while sprint bouts were performed on a specialized self-propelled treadmill (HiTrainer, QC, Canada) against no resistance to allow participants to sprint “all-out”. Participants ran at maximal effort for the full sprint duration after which they remained on the treadmill and could walk slowly during recovery. The treadmill interface provided audio prompting to begin and stop running and verbal encouragement was provided throughout.

**Measures**

The primary psychological variables of interest were affect, exercise task self-efficacy, intentions, enjoyment, and preference; measures were similar to Jung et al. (2014). Much more research has been performed on the perceptions of HIIT and has also compared HIIT to MICT (Bartlett et al. 2011; Jung et al. 2014), thus it is valuable to measure similar constructs during SIT to allow for comparisons with these exercise protocols. Briefly, in-task affect was assessed at 4.5, 9, 13.5 min and immediately-post SIT (see Figure 1; Table 1) by asking participants to verbalize their perceptions while being provided the scale for visual reference (Hardy and Rejeski 1989). These times translated into (a) after each sprint within the 30:240 trial, (b) every
second sprint within the 15:120 trial, and (c) every sixth sprint for the 50:40 trial. This study was designed to determine how exercise protocols were perceived compared to one another, which would be unaffected by making assessments immediately following sprint bouts. Thirty minutes post-exercise we further assessed affect, self-efficacy (McAuley and Mihalko 1998), intentions (Jung et al. 2014), and enjoyment (Physical Activity Enjoyment Scale; PACES) (Kendzierski and DeCarlo 1991) while participants sat comfortably in a chair and entered their responses onto a hardcopy. The PACES scale was modified similar to Jung et al. (2014) by removing one irrelevant item (current absorption in the activity) and adding two questions (see Table 2). Participants in the current project were wearing a respiratory mask for 30 min post-exercise (Islam et al. accepted). Thus, to avoid any confounding factors, we waited until the mask was removed to assess perceptions of the exercise. Furthermore, by means of comparison to Jung et al.’s study (2014), we first analyzed task self-efficacy as a mean of the aggregate score of the 5-item measure but additionally analyzed responses to each individual item separately to gather a more comprehensive understanding of perceived self-efficacy. To assess preference of exercise protocol, participants returned for a 4th session serving as a “deception” session where they were instructed to be prepared to perform another SIT session but were not told which session they would be asked to perform. Upon arrival, participants were informed that they could choose which of the three previous SIT protocols they would prefer to perform, and their selection served as an indicator of preference. Following their selection, participants were informed that they did not in fact need to perform the exercise and were able to leave the laboratory.

**Statistical Analysis**

A 3 (session) by 6 (time point) repeated measures ANOVA (within subjects) was
conducted to examine differences in affect pre-, during (4.5, 9, 13.5 min), immediately post-
exercise, and 30-minutes post-exercise. In addition, a series of one-way ANOVA were 
conducted to examine differences in self-efficacy, intentions, and enjoyment, following the three 
SIT protocols. Whenever required, pairwise comparisons were conducted using LSD. A 
criterion of \( p < 0.05 \) was used for all analyses. All data are presented as means ± standard 
deviations (see Table 2 and Figure 2).

RESULTS

Manipulation Check

Participants had an average \( \text{VO}_2\max \) of 48.9±5.3 ml·kg\(^{-1}\)·min\(^{-1} \). Participant heart rate, 
oxygen consumption, and running speed during exercise support that all participants were 
working maximally during sprints. For detailed information please see companion paper (Islam 
et al. accepted).

Affective Response

Mauchly’s test indicated the assumption of sphericity had been violated; therefore, 
degrees of freedom were corrected using Greenhouse-Geisser estimates (\( \epsilon = 0.6 \) for main effect 
of session and 0.54 for main effect of time). The results identified significant main effects for 
time, \( F(2.68, 21.49) = 31.21, p < 0.001, \eta^2_p = 0.79 \), and an exercise session x time interaction, 
\( F(3.2, 25.63) = 3.16, p = 0.039, \eta^2_p = 0.28 \). There were no differences in pre-exercise affect or 
affect perceptions at the first exercise time point (Figure 2). However, affect was significantly 
higher for 5:40 compared to 30:240 at the third, \( F(1, 8) = 8.62, p = 0.019 \), fourth, \( F(1, 8) = 7.69, 
p = 0.024 \), and fifth, \( F(1, 8) = 5.99, p = 0.04 \), exercise time points (Figure 2). Moreover, affect
30 minutes post-exercise was significantly greater for both the 5:40 ($p = 0.014$) and 15:120 ($p = 0.015$) compared to 30:240, $F(1, 8) = 9.74$.

**Task self-efficacy**

When responses to the 5-item self-efficacy questionnaire were aggregated and analyzed similar to Jung et al. (2014), results suggested that participants felt significantly more confident $F(2, 16) = 15.85$, $p < 0.001$, $\eta_p^2 = 0.67$, in their ability to perform 5:40 ($p = 0.001$) and 15:120 ($p = 0.008$) compared to 30:240 (Table 2). No difference was seen between 5:40 and 15:120 ($p = 0.203$). However, closer inspection provided more important information. Responses to individual task self-efficacy items yielded consistency across individuals’ beliefs about their ability to engage in SIT 1-5 times per week; for each frequency, participants expressed greater confidence in their ability to perform 5:40 and 15:120 protocols compared to 30:240, $F(1, 8) = 14.00, 21.56, 27.23, 13.79, 9.46$, respectively, all $p$s < .05, $\eta_p^2 = 0.51, 0.65, 0.67, 0.54, 0.48$, respectively (see Table 2). In response to the question “how confident are you that you could pace yourself to avoid over-exertion?” participants expressed significantly greater confidence in 5:40 ($p = 0.001$) and 15:120 ($p = 0.05$) compared to 30:240, $F(1, 8) = 25.30$, $\eta_p^2 = 0.57$. Lastly, confidence to perform all required movements was greater for 5:40 compared to 30:240 ($p = 0.025$), $F(1, 8) = 7.54$, $\eta_p^2 = 0.38$.

**Intentions**

Participants expressed significantly greater intentions, $F(1.15, 9.17) = 6.88$, $p = 0.03$, $\eta_p^2 = 0.46$, to perform 5:40 three/week compared to both 15:120 ($p = 0.035$) and 30:240 ($p = 0.025$), and responses regarding 15:120 were also greater compared to 30:240 ($p = 0.044$) (see Table 2);
degrees of freedom were corrected using Greenhouse-Geisser estimates ($\varepsilon = 0.57$). Intentions to perform SIT five times/week were significantly greater, $F(2, 16) = 4.97, p = 0.02, \eta^2_p = 0.38$, for 5:40 compared to 30:240 ($p = 0.028$), though not in comparison to 15:120.

**Enjoyment**

There was a main effect of session, $F(2, 16) = 7.22, p = 0.006, \eta^2_p = 0.47$, in response to the question “how much did you enjoy the exercise that you completed today?”. Participants expressed significantly greater enjoyment of 5:40 ($p = 0.008$) and 15:120 ($p = 0.047$) compared to 30:240 (Table 2). Similarly, the anticipated enjoyment of performing the same exercise protocol 3/week over the next month was significantly greater for 5:40 ($p = 0.007$) and 15:120 ($p = 0.009$) compared to 30:240 (Table 2), $F(2, 16) = 9.59, p = 0.02, \eta^2_p = 0.55$. Pairwise comparisons of the modified PACES, $F(2, 16) = 5.95, p = 0.01, \eta^2_p = 0.41$, indicated that 5:40 was significantly more enjoyable than 15:120 ($p = 0.025$) and 30:240 ($p = 0.026$) with no difference between 15:120 and 30:240 ($p = 0.201$) (Figure 3; Table 2).

**Preference**

When given the option at the onset of the deception session, all participants verbally selected the 5:40 exercise protocol over the other protocols.

**DISCUSSION**

The current study aimed to determine if manipulating the sprint and recovery durations, while maintaining the same 1:8 work to rest ratio as traditional SIT, could uncover more favourable perceptions of SIT. The key findings of this study support our hypotheses that the
5:40 protocol would be the most enjoyable, elicit the most positive during and post-exercise affect, and be preferred by all participants. Further support was demonstrated by the greater intentions to perform the 5:40 protocol 3 and 5/wk and greater confidence in the ability to perform 5:40 and 15:120 compared to 30:240. These data suggest that shorter sprints with more repetitions produce more positive psychological perceptions of exercise and lead to greater intentions to engage in modified SIT, at least in healthy active individuals. We will discuss these promising results in light of the current debate surrounding SIT’s use as an exercise strategy for the general public.

The first contention in the SIT debate is that the high intensities of SIT could produce negative affective responses thereby making people unlikely to perform the exercise (Hardcastle et al. 2014; Biddle and Batterham 2015). Indeed, our data seem to support the idea that traditional 30 s SIT is perceived as unpleasant (Hardcastle et al. 2014; Saanijoki et al. 2015). We show here that within SIT, performing more repetitions of reduced duration sprints produces better affective responses compared to traditional 30 s SIT. It should also be noted that based on the current data, and past research (Metcalf et al. 2011; Gillen et al. 2014), one of the best ways to maintain positive affect is to minimize total exercise and session duration (1 min exercise during <10 min). However, these studies have not observed improvements in body composition even in previously sedentary (Metcalf et al. 2011) and overweight participants (Gillen et al. 2014) whereas traditional SIT (~2 min exercise during ~18 min session) has shown to be effective (Whyte et al. 2010; MacPherson et al. 2011; Hazell et al. 2014). With this in mind, there may be a minimum exercise duration required to expend adequate energy to achieve weight loss and it is important to find ways to increase the psychological tolerability of these programs, as we have done. Our data complement previous findings demonstrating that reduced duration
sprint bouts elicit more positive affective responses (Martinez et al. 2015). For example, Martinez and colleagues (2015) found that affect remained more positive throughout shorter sprint bouts when SIT sessions maintained the same work to rest ratio (1:1) but varied only in sprint duration (30, 60, and 120 s).

Considering traditional SIT is already highly demanding (Biddle and Batterham 2015), the practicality of longer sprints as utilized in the Martinez et al. (2015) study is questionable and our results are potentially more meaningful to the general population. In our companion paper we demonstrate greater energy expenditure during reduced duration SIT (5 and 15 s) compared to traditional SIT (Islam et al. Submitted) and we show here that both of our shorter duration SIT protocols resulted in near pre-exercise affect levels 30 min post-exercise and were evaluated as more enjoyable 30 min post-exercise. Moreover, the anticipated enjoyment of performing 5:40 and 15:120 protocols 3/wk over the next month was greater than 30:240. A rebound in post-exercise affect was previously observed following HIIT protocols (Oliveira et al. 2013; Jung et al. 2014) and studies consistently demonstrate that HIIT/SIT are perceived as enjoyable when assessed post-exercise (Bartlett et al. 2011; Oliveira et al. 2013; Jung et al. 2014; Martinez et al. 2015; Kilpatrick et al. 2015a). Taken together, because affective responses and perceived enjoyment can positively influence future exercise participation, at least during MICT (Rhodes et al. 2010), future research should perform long-term training studies utilizing our reduced duration sprint protocols to assess their potential as alternatives to traditional SIT.

Another critique of SIT is that it will be perceived as too difficult and people will not feel sufficiently confident to engage in such a demanding protocol (Hardcastle et al. 2014). We found that self-efficacy was significantly greater for the 5:40 and 15:120 protocols compared to
30:240. Since self-efficacy is one of the strongest and most consistent correlates of PA (Trost et al. 2002; Bauman et al. 2012), the reduced duration SIT protocols used in this study may be more likely to be adopted. Interestingly, despite lower affective scores during HIIT compared to MICT, Jung and colleagues (2014) found that inactive people felt just as confident in their ability to perform HIIT, and self-efficacy scores for both HIIT and MICT were greater than vigorous-intensity continuous exercise. This led Jung et al. (2014) to suggest that vigorous interval exercise possesses specific characteristics that may bolster confidence that are not garnered by vigorous-intensity continuous exercise. More specifically, dividing exercise into brief, more achievable, efforts affords the exerciser opportunities to experience success over the previous sprint (Jung et al. 2014), which may further explain why our protocol with the greatest number of sprints and rest periods had the greatest self-efficacy in the current project.

A second important point related to efficacy pertains to participant responses to specific frequencies of exercise/wk. In the current study, confidence remained high for performing SIT 1-3/wk but precipitously dropped at 4-5/wk for all protocols, although 30:240 produced a more rapid and profound decline (Table 2). This suggests that there could be an optimal frequency of SIT/wk. Our 5:40 and 15:120 protocols appear to be perceived as highly tolerable up to 3/wk, which is in line with past SIT exercise training research (Hazell et al. 2010; Metcalfe et al. 2011; Gillen et al. 2014). Thus, it is promising that reduced duration sprint protocols can produce meaningful health and fitness adaptations while also allowing people to express high confidence in their ability to perform modified SIT 3/wk.

Possibly reflecting the more favourable perceptions of the 5:40 protocol outlined above, our participants also expressed greater intentions and preferences to participate in this protocol, potentially indicating a greater likelihood for behavioural adoption of modified SIT. Participants
expressed high intentions to engage in SIT 3/wk but far lower intentions for 5/wk, similar to self-efficacy, supporting our earlier idea that there might be an optimal frequency of SIT/wk.

Although intention is an established correlate of PA (Bauman et al. 2012), ~36% of individuals who intend to be active will fail (Rhodes and de Bruijn 2013). Thus, forming intentions are important for PA engagement but they are often not converted to action (Williams et al. 2008). However, affective judgments and enjoyment of PA have been suggested to positively influence the translation of intention into action (Rhodes and de Bruijn 2013). Taken together, since our participants reported more positive affective responses and greater enjoyment of modified SIT, we speculate that there is some likelihood that intentions will translate into behaviour with these protocols.

The design of the present study, however, precluded an examination of real-world behavioural choices beyond the intervention. To address this issue, future research should incorporate direct follow-up measures of behaviour to provide greater insight into the likelihood of successful intention translation. In order to contribute to the debate on the acceptability of SIT, investigation comparing intention-behaviour translation after modified SIT and MICT is also warranted. Another boundary to the present research was our emphasis on assessing the efficacy of SIT under controlled conditions. Experiencing SIT in real-world conditions (i.e., outside of a laboratory setting), and/or in different social environments (e.g., group exercise), could influence the psychological responses. Only recently has interval training begun to be assessed outside of the laboratory (Lunt et al. 2014) and in social environments (Shepherd et al. 2015; Martin et al. 2016). Finally, the present sample consisted of nine recreationally active male volunteers, although recent research suggests that active and inactive individuals express dissimilar affective responses to HIIT (10 x 60 s work bouts at 90% max running speed) (Frazão
et al. 2016). Therefore, future research will be needed to explore whether our results translate to inactive populations. Finally, we maintained the traditional 1:8 work to rest ratio but appreciate that this is not a requirement of SIT. The issue of SIT-tolerability will be influenced by work intensity and the amount of rest between each bout, thus future research should manipulate both of these factors to continue developing more tolerable SIT protocols.

We have demonstrated that reducing the duration of sprints while increasing the number of repetitions can produce more positive psychological perceptions compared to traditional SIT while maintaining the acute physiological effects (Islam et al. accepted). Affective responses, self-efficacy, intentions, enjoyment, and preferences all indicate that our 5:40 protocol is a promising alternative to traditional SIT. These findings contribute meaningfully to the current debate surrounding SIT by demonstrating that SIT can be modified in a psychologically favourable direction. Taken together, our systematic physiological and psychological evaluations show promising results that could inform the delivery of future SIT programs and interventions and add to the ongoing debate in this area.

**CONFLICT OF INTEREST**

The authors report no conflicts of interest associated with this manuscript.

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does not diminish maximal and submaximal performance gains in healthy men. European
25091854.
Table 1 - Summary of Assessment Tools

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<td>Affect (Feeling Scale; 14)</td>
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<td>Scale from 1-9 - each item compared individually</td>
</tr>
<tr>
<td>Preference</td>
<td>1</td>
<td>“If you could choose to perform any of the exercise protocols you completed during this study, which would you choose to perform?”</td>
<td>Verbal confirmation</td>
</tr>
</tbody>
</table>

Note. *modified PACES removed question #5 on “I am very absorbed in the activity – I am not at all absorbed in the activity” as it was irrelevant due to measurement time point in line with previous methodology (15)
Table 2 – Post-exercise psychological assessments

<table>
<thead>
<tr>
<th>Construct</th>
<th>Variable</th>
<th>30 min post-exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>5:40</td>
</tr>
<tr>
<td>Task Self-efficacy</td>
<td>Confidence in performing 1/wk for next month</td>
<td>9.89±0.33&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Confidence in performing 2/wk for next month</td>
<td>9.78±0.67&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Confidence in performing 3/wk for next month</td>
<td>8.67±1.22&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Confidence in performing 4/wk for next month</td>
<td>5.89±3.06&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Confidence in performing 5/wk for next month</td>
<td>5.11±3.14&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Carry out the SIT session for the planned duration?</td>
<td>9.33±1.66</td>
</tr>
<tr>
<td></td>
<td>Avoid over-exertion?</td>
<td>9.22±1.20&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Perform all required movements?</td>
<td>9.78±0.44&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Check how hard your activity is making you work?</td>
<td>8.44±1.42</td>
</tr>
<tr>
<td></td>
<td>Follow the directions of the instructor/trainer?</td>
<td>9.78±0.44</td>
</tr>
<tr>
<td>Aggregate self-efficacy score&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.87±1.27&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.22±2.12&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Intentions</td>
<td>Perform 3/wk for next month</td>
<td>5.00±1.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Perform 5/wk for next month</td>
<td>2.89±1.76&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>“How much did you enjoy…”</td>
<td>7.11±1.17&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Enjoyment performing 3/wk for next month</td>
<td>5.11±3.14&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Modified PACES&lt;sup&gt;c&lt;/sup&gt;</td>
<td>96.6±1.0&lt;sup&gt;abc&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup> - significantly different vs 30:240 (P<0.05); <sup>b</sup> - significantly different vs 15:120 (P<0.05); <sup>c</sup> - in line with methods from Jung et al. 2014
Figure Captions

**Figure 1:** Sample timeline of experimental session relative to companion paper. Arrows indicate measurement time points.

**Figure 2:** Feeling Scale (affect) responses measured before, during, and after the exercise sessions. The Table presents data as mean ± SD. $^a$ – significantly different vs 30:240 (P<0.05). $^b$ – significantly different vs 15:120 (P<0.05)

**Figure 3:** Enjoyment of all 3 exercise sessions. $^a$ – significantly different vs 30:240 ($p = 0.026$). $^b$ – significantly different vs 15:120 ($p = 0.025$)
Figure 2: Feeling Scale (affect) responses measured before, during, and after the exercise sessions. The table presents data as mean ± SD. 

- $a$ – significantly different vs 30:240 ($P<0.05$).
- $b$ – significantly different vs 15:120 ($P<0.05$)

74x59mm (300 x 300 DPI)
Figure 3: Enjoyment of all 3 exercise sessions.  

- significantly different vs 30:240 (p = 0.026).  
- significantly different vs 15:120 (p = 0.025)