ORIGINAL RESEARCH

Sprint Interval Training: Recovery Format, Enjoyment and Blood Pressure in Inactive Men

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ABSTRACT

Background: While the efficacy of sprint interval training (SIT) to provide positive health effects in inactive populations is established, feasibility is associated with enjoyment and safety, which are dependent on the acute physiological and perceptual responses. The recovery format likely influences physiological and perceptual responses that occur during and immediately after SIT. It was hypothesized that during SIT interspersed with active recovery periods, enjoyment and blood pressure (BP) values would be higher compared with passive recovery periods, in inactive participants.

Methods: Twelve males (mean ± SD; age 23 ± 3 y) completed 3 exercise sessions on a cycle ergometer in a randomized order on separate days: (a) SIT with passive recovery periods between 4 bouts (SITPASS), (b) SIT with active recovery periods between 4 bouts (SITACT), and (c) SITACT with the 4 SIT bouts replaced with passive periods. BP was measured immediately after each bout and every 2 min during a 6 min recovery. Physical activity enjoyment was measured during postexercise recovery.

Results: There were no significant differences in physical activity enjoyment or systolic BP between SITPASS and SITACT. Diastolic BP was lower during recovery in SITACT ($P = 0.025$) and SITPASS ($P = 0.027$), compared with resting BP. Furthermore, diastolic BP was lower after 6 min of recovery following SITPASS, compared with SITACT ($P = 0.01$).

Conclusion: Exercise enjoyment and acute systolic BP responses were independent of SIT recovery format in inactive men. Reductions in diastolic BP were greater and more prolonged after SIT protocols that included passive recovery periods. *Journal of Clinical Exercise Physiology*. 2021;10(3):75–84.

Keywords: High intensity interval training, inactivity, physical activity enjoyment scale, post exercise hypotension

INTRODUCTION

Sprint interval training (SIT) has been proposed as a time-efficient exercise format to improve exercise compliance and provide health benefits for insufficiently active individuals, particularly younger individuals (1). While the efficacy of high-intensity interval training, including SIT, to improve parameters such as glycemic control and cardiorespiratory fitness is well established (1–4), the feasibility of SIT is less clear. In a clinical and behavioral-change context, feasibility is associated with the enjoyment and perceived safety of this exercise format, which are, in turn, largely dependent on the physiological responses and sensations resulting from the exercise stimulus. SIT is associated with aversive sensations (5–7), which can have a direct negative effect on exercise enjoyment, perceived safety, and therefore adherence (8,9), particularly in inactive populations who often have low intrinsic motivation to exercise (10,11).

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Previous studies of enjoyment during high-intensity exercise have yielded inconsistent findings: inactive individuals are more likely to enjoy and be compliant with exercise that they perceive as moderate in intensity (8), however SIT has been shown to be enjoyable and is associated with a degree of positive affect (mood state) (12). Additionally, no difference in enjoyment has been reported when comparing a session of SIT with continuous moderate-intensity exercise (5,13). However, it is proposed that factors other than exercise bout intensity contribute to enjoyment (14,15). Synergistic to the exercise component during SIT is the intrabout recovery periods. The recovery periods are an integral part of the SIT session, as these periods modulate the physiological responses and perceptual sensations that occur during and after an acute session of SIT. The 2 most frequently used recovery formats are *active* and *passive* recovery. The performance benefits of active versus passive recovery have been investigated in trained populations, however results are mixed as to which recovery strategy is deemed beneficial in a performance context potentially because of differences in the specific performance-related physiological measurements investigated (16–21). Importantly, in relation to optimizing the uptake of SIT for health, the influence of active and passive recovery formats on inactive individuals' enjoyment levels during SIT has not been established. It is proposed that, as active recovery may promote more efficient clearance of metabolites (22), improved blood flow, and decreases in muscle discomfort (23) compared with passive recovery, active recovery could potentially increase the enjoyment of SIT. By comparing enjoyment levels between these 2 recovery formats, it will be possible to identify which format is more likely to promote exercise initiation and adherence.

The safety of SIT in inactive individuals has been debated (24–27), partly because high-intensity exercise is associated with a transient elevated risk of adverse cardiovascular events and symptoms, especially in individuals attempting unaccustomed or infrequent exercise (28,29). The mechanisms by which high-intensity exercise induces adverse cardiovascular events are unclear, but a proposed trigger is the vascular wall stress associated with increases in blood pressure (BP) and flow, potentially leading to atherosclerotic plaque disruption (30). Furthermore, a hypertensive or exaggerated response to an acute session of exercise is associated with an increased risk of hypertension even in the presence of normal resting BP and various other markers of cardiovascular disease risk, including mortality (31–33). It is plausible to expect acute hypertensive or exaggerated BP responses during supramaximal SIT. However, passive recovery periods during a SIT session, compared with active recovery periods, would potentially allow for a greater reduction in systolic blood pressure (SBP) during the recovery periods and therefore lower the overall SBP response during an acute session of SIT. Moreover, acute adverse symptoms associated with postexercise hypotension (PEH) have been linked to SIT (7,34) and inactive status (35). Additionally, young adults are heavily represented in the symptomatic PEH literature (36). Symptomatic PEH is potentially more likely after SIT that includes passive recovery periods, as the secondary muscle pump is not active throughout the session (37). The sensations of dizziness, nausea, near syncope or syncope that accompany symptomatic PEH (7,37,38) could negatively affect enjoyment levels. The effect of active versus passive recovery format on acute BP responses, in inactive individuals, is unknown. Ascertaining this information will allow insight into the contribution of BP responses to safety and enjoyment aspects of SIT.

The aim of this study was therefore to compare the effect of sessions of SIT, which included either passive or active recovery periods, on the enjoyment and BP responses of inactive participants. It was hypothesized that in young inactive men, during a session of SIT including active recovery periods, compared with a session of SIT including passive recovery periods, enjoyment and BP would be higher.

METHODS

Ethics Statement

This research study was approved by the human research ethics committee of the University of the Sunshine Coast (S/13/472). All participants received a research study information sheet before providing written informed consent.

Experiment Design

The experiment consisted of 3 conditions conducted on a bicycle ergometer: (a) SIT with passive recovery periods between each bout (SITPASS), (b) SIT with active recovery periods between each bout (SITACT), and (c) a protocol in which only the active recovery periods were completed, and the bouts of SIT were replaced with passive periods (REC), in order to provide an indication of inactive individuals' perceptual and physiological responses to a low-intensity interval exercise session. Additionally, the inclusion of the REC condition allowed researchers the opportunity to understand the isolated effects of the active recovery periods. The conditions followed a Latin square crossover design to control for a possible order effect. All testing sessions were separated by 3 to 7 d to minimize the influence of any potential carry-over effects or confounding variables between sessions. The conditions and the timing of measurements are illustrated in Figure 1.

Participants

The participant group consisted of 12 men who met the inclusion criteria of being aged 18 to 30 y, were currently completing less than 150 min of moderate-intensity or 75 min of vigorous-intensity activity per week, reported no cardiovascular and metabolic disease, were taking no medications, and had no known health-related issues that would be made worse by or inhibit participation in the sessions. Descriptive physical characteristics of the participants are presented in Table 1.

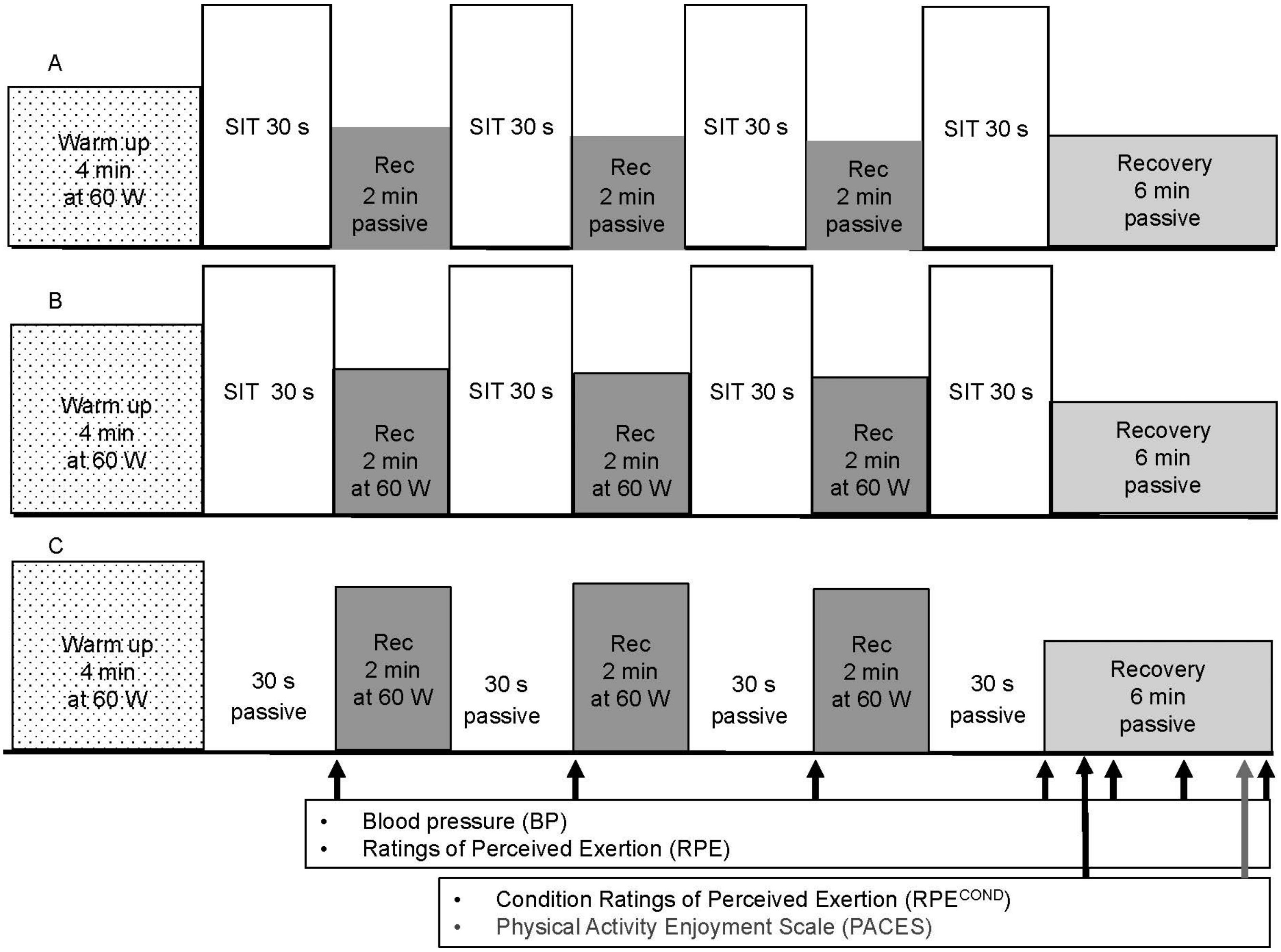

FIGURE 1. The structure and timing of measurements of the 3 conditions: (A) SITPASS, (B) SITACT, (C) REC. Rec = recovery; SIT = sprint interval training; SITACT = SIT with active recovery periods between 4 bouts; SITPASS = SIT with passive recovery periods between 4 bouts.

PROCEDURES AND EQUIPMENT

Screening Procedures

At the initial session, participants completed risk screening questionnaires and a physical activity log, and physical characteristics of height, mass, and resting pulmonary function were measured (Table 1) (39). The physical activity log was used to ensure that participants' activity levels during the previous 3 months were within the definition of inactive for the purposes of this experiment (i.e., not achieving the minimal exercise recommendations to gain health benefits) (40). Participants were asked to maintain their normal dietary patterns, not perform any exercise in the 24 h preceding each session, and to not consume any caffeine, alcohol, or a meal in the 4 hours preceding a session. It was confirmed at each testing session that participants were adequately fed and hydrated in line with pre-exercise guidelines (41). Participants were asked to complete all test sessions at approximately the same time of day to control for potential changes in BP due to circadian rhythms.

TABLE 1. Participant characteristics.

Parameter	Value, mean ± SD (n = 12)
Height (cm)	176 ± 8.36
Weight (kg)	78.2 ± 13.8
Age (y)	23 ± 3.21
Reported weekly physical activity time (min)	37 ± 47
FVC (L)	5.40 ± 0.77
FVC % predicted (%)	105 ± 10.2
FEV_1 (L)	4.54 ± 0.72
FEV_1 % predicted (%)	104 ± 10.9

FEV_1 = forced expiratory volume in 1 s; FVC = forced vital capacity

Exercise Conditions and Measures

The format of the experiment conditions is illustrated in Figure 1. Prior to the first exercise session, participants were familiarized with the cycle ergometer (Velotron, Racermate, Seattle, Washington) and the testing protocol. Participants were instructed to remain seated throughout each condition to allow for consistency in muscular recruitment patterns and work. Each condition consisted of an initial 5-min seated rest period followed by a baseline data collection period of 3 min, while participants remained stationary on the cycle ergometer. Exercise began with a 4 min warm-up period, which consisted of cycling against a fixed resistance of 60 Watts. The warm-up was followed by four 30-s bouts of high-intensity exercise in the SITPASS and SITACT conditions, with 2-min recovery periods separating each high intensity bout.

The intensity of the SIT bouts was determined by participant effort against resistance (0.075 kg per kilogram body weight), applied to the flywheel of the ergometer (42). The SIT format and timings were adapted from protocols used previously in trained and untrained populations (43–46). Participants were instructed to give a maximal effort from the beginning of each bout. During the passive recovery periods of the SITPASS condition, participants were instructed to sit still. During the active recovery periods of the SITACT and REC conditions, participants were instructed to pedal against a resistance of 60 Watts (approximately 30%-40% $\dot{V}o_{2max}$) (19), an intensity shown to promote optimal clearance of metabolites (22,47). During the REC condition, the 4 high-intensity exercise bouts were replaced by periods of passive rest. At the completion of all exercise conditions, there was a 6-min passive recovery period.

To quantify the heart rate (HR) response as a physiological measure of the exercise intensity of each of the SIT exercise conditions in their entirety (including exercise periods and interbout recovery periods), a HR monitor (RS400, Polar Electro, Kempele, Finland) was used continuously from resting baseline period until condition end. To quantify perceived exercise intensity of each condition, participants were provided with a standardized description of the 10-point category-ratio ratings of perceived exertion (RPE) scale (48) and the scales purpose, including memory anchoring of the scale (an explanation of the sensations associated with the high-scale and low-scale categories) (49). Participants were asked to provide an RPE score immediately after each bout of SIT as well as give a *condition* RPE score (RPE^{COND}) 1 min after the final (fourth) bout. This RPE^{COND} score reflected the overall perception of exertion associated with the 3 conditions.

To quantify participants' enjoyment of each condition, participants completed the physical activity and enjoyment scale (PACES) questionnaire within 5 min of completing each condition (after the final recovery period). The PACES consists of 18 items on a 7-point bipolar scale. A minimum total score of 18 and a maximal total score of 126 is possible.

To quantify SBP and diastolic blood pressure (DBP) responses during the 3 experimental conditions, a manual BP cuff, aneroid, and stethoscope (Welch Allyn, New York, New York) were used. The measurements were taken at rest (in the position of exercise), immediately after each bout of high-intensity exercise (and equivalent timings during the REC condition) and every 2 min during the 6 min postexercise recovery period (Rec 2, Rec 4, and Rec 6). Mean arterial pressure (MAP) was calculated for each time point.

Data Calculation and Statistics

Group mean values were calculated for HR, RPE, PACES, SBP, DBP, and MAP data at each measurement time, providing a single value per measurement time for statistical analysis. Statistical tests were performed using IBM SPSS Statistics (version 22, IBM Corporation, Armonk New York). Data was initially screened for normality of distribution using a Shapiro-Wilk test. A two-factor repeated-measures analysis of variance (ANOVA) was used to analyze the effect of condition and bout on the dependent variables of RPE, SBP, DBP, and MAP. If a significant main effect or interaction was identified, a Bonferroni post hoc test was used to make pairwise comparisons. The effect of condition on HR, RPE^{COND}, and PACES scores was analyzed using a 1-way ANOVA. The Mauchly *W* test was used to evaluate sphericity for each dependent variable. Where applicable either the Greenhouse-Geisser correction or the Huynh-Feldt adjustment was used to address violation of sphericity. All variables are presented as mean ± SD. For all statistical analyses, a *P* value of <0.05 was accepted as the level of significance.

RESULTS

As expected, due to study design, differences in mean mechanical work were found between the 3 experiment conditions ([$P < 0.001$] SITPASS 45 ± 7 kJ, SITACT 63 ± 8 kJ, REC 22 ± 1 kJ). Resting HR was not different between conditions (SITPASS = 79 ± 12, SITACT = 80 ± 10, and REC = 76 ± 8). However, the mean HR of each SIT session (including both exercise bouts and interbout recovery portions), while lower during REC (105 ± 6 $b{\cdot}min^{-1}$) ($P < 0.001$), was not statistically different between SITPASS (152 ± 15 $b{\cdot}min^{-1}$) and SITACT (159 ± 11 $b{\cdot}min^{-1}$).

Additionally, while RPE increased with each bout in SITPASS ($P < 0.001$) and SITACT ($P < 0.001$), there was no difference in RPE between SITPASS and SITACT (Figure 2A). For RPE^{COND}, there was a main effect for condition ($P < 0.001$), however no differences were found between SITPASS and SITACT (Figure 2B).

For the mean PACES score, no differences were found between the 3 conditions (Figure 3).

SBP increased during the interbout recovery portions of each condition, compared with resting levels, and returned to near baseline by Rec 6 ($P < 0.001$) (Figure 4A). The SBP response to REC was lower than to the 2 SIT conditions. No differences were found between the 2 SIT conditions ($P < 0.001$).

DBP was lower during the recovery portions of SITPASS ($P = 0.001$) and SITACT ($P = 0.001$), compared with resting levels. DBP during the REC condition remained stable throughout. Differences in DBP were found between the 2 SIT conditions for Rec 6 only, in which DBP was lower in SITPASS, compared with SITACT.

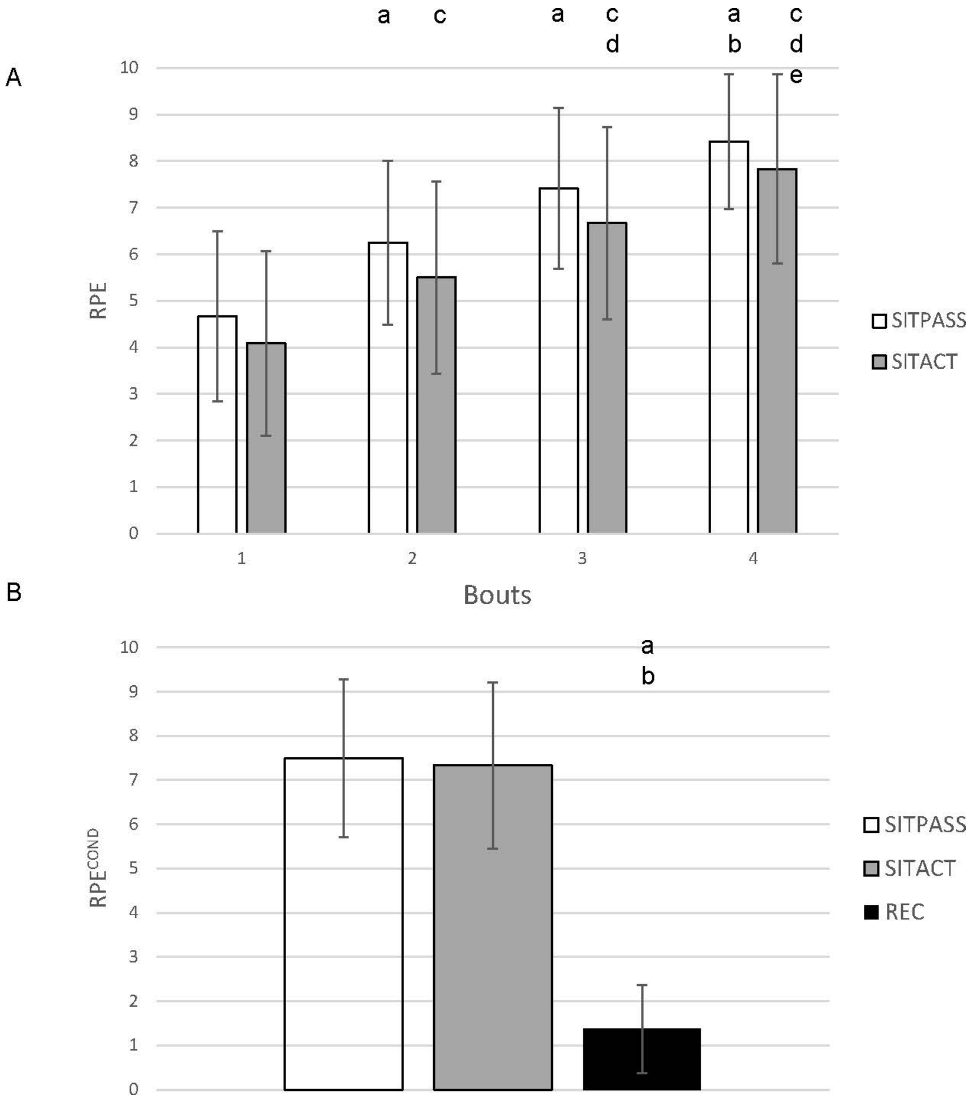

FIGURE 2. Ratings of perceived exertion and condition ratings of perceived exertion for the 3 conditions. (A) RPE: a = significantly different to SITPASS bout 1, b = significantly different to SITPASS bout 2, c = significantly different to SITACT bout 1, d = significantly different to SITACT bout 2, e = significantly different to SITACT bout 3; (B) RPE^{COND}: a = significantly different to SITPASS; b = significantly different to SITACT. Data are mean ± SD. ($P \leq 0.05$). RPE = ratings of perceived exertion; RPE^{COND} = condition ratings of perceived exertion; SITACT = sprint interval training with active recovery periods between 4 bouts; SITPASS = sprint interval training with passive recovery periods between 4 bouts.

MAP increased during the interbout recovery portions of each condition, compared with resting levels, before declining to near baseline by Rec 6 (*P* = 0.002). No significant differences were found between protocols for MAP.

Presyncopal symptoms of dizziness and/or nausea were noted in 6 participants during the passive recovery after exercise (3 after SITPASS, 2 after SITACT and 1 after both conditions).

DISCUSSION

The aim of this experiment was to compare the effect of sessions of SIT, which included either passive or active recovery periods, on the PACES and BP responses of inactive participants. There were no differences in PACES or SBP during SITPASS, compared with SITACT. DBP was lower after 6 min of recovery following SITPASS, compared with SITACT.

Physical Activity Enjoyment Scale

No previous research has compared enjoyment between SIT sessions including either active or passive recovery periods. Four studies have compared enjoyment between SIT sessions with different interbout recovery duration (40,50–52). However, these studies altered both exercise bout and recovery period duration and used a variety of exercise modes (cycling, running, and arm-only exercise). Three of these studies found no difference in enjoyment (40,50,51) while 1 found increased enjoyment during sessions incorporating

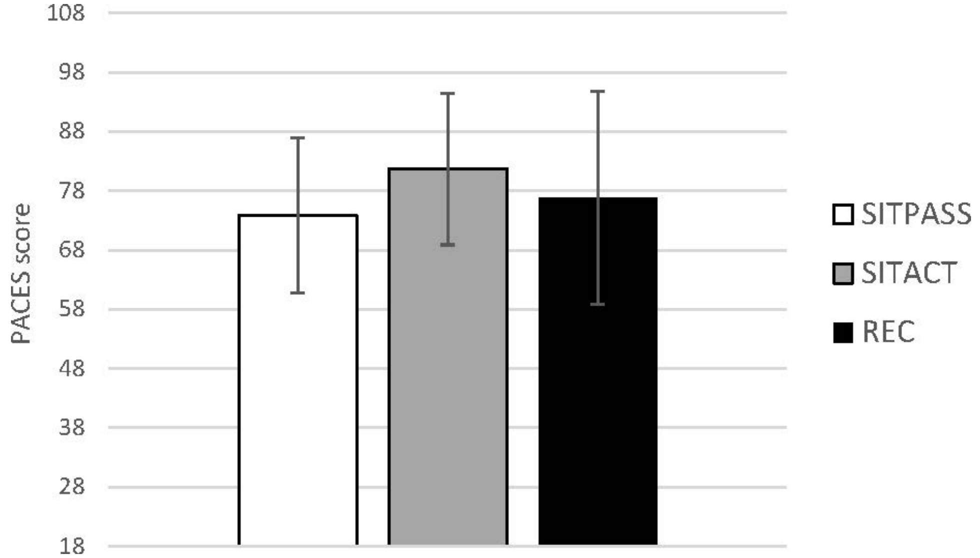

FIGURE 3. Physical activity enjoyment scale for the 3 conditions. Data are mean ± SD. ($P \leq 0.05$). PACES = physical activity enjoyment scale.

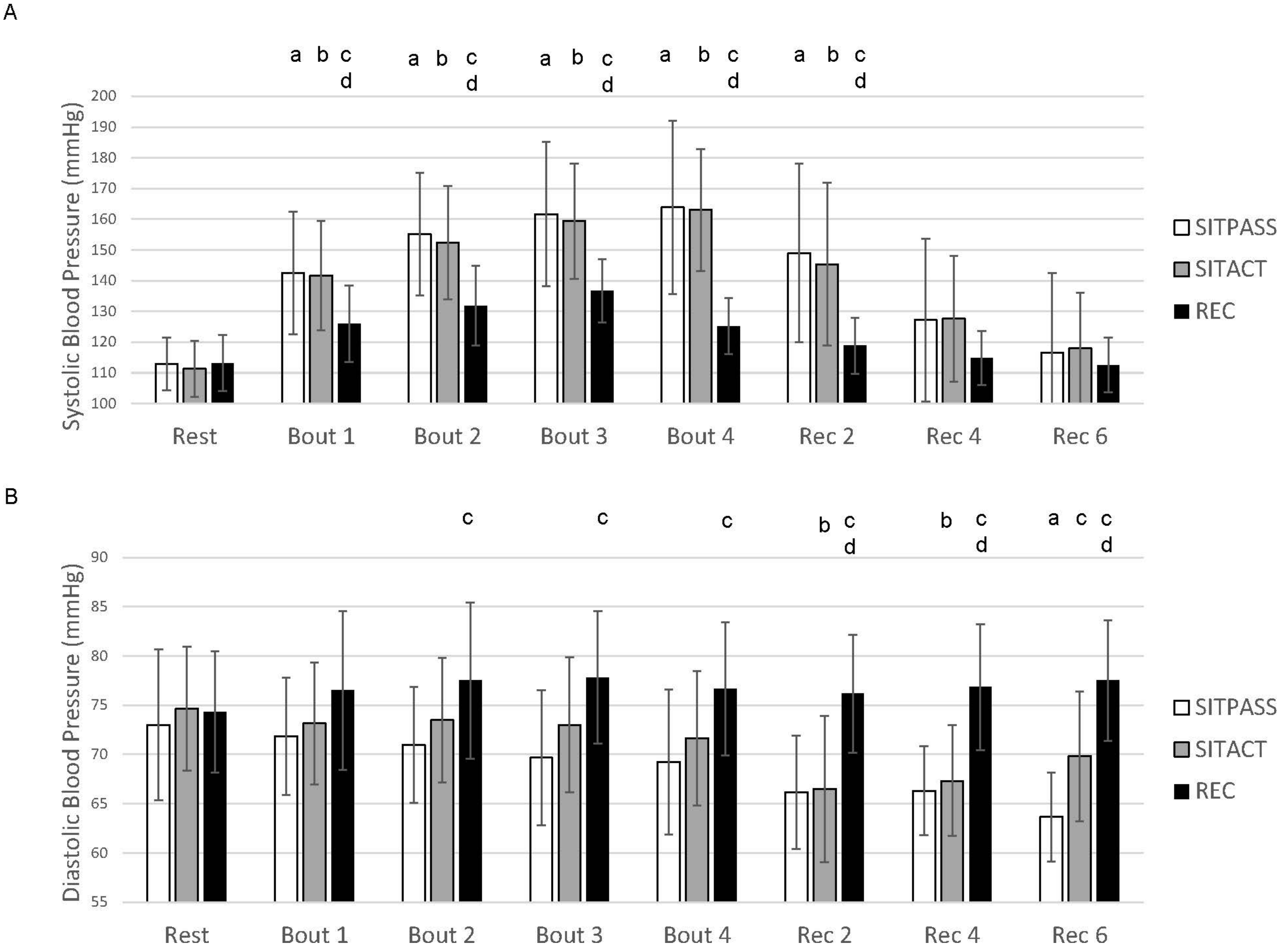

FIGURE 4. Systolic and diastolic blood pressure responses during the 3 conditions. (A) SBP: a = significantly different to SITPASS rest, b = significantly different to SITACT rest, c = significantly different to REC rest, d = significantly different to SIT conditions at same time; (B) DBP: a = significantly different to SITPASS rest, b = significantly different to SITACT rest, c = significantly different to SITPASS at same time, d = significantly different to SITACT at same time. Data are mean ± SD. ($P \leq 0.05$). DBP = diastolic blood pressure; SBP = systolic blood pressure; SIT = sprint interval training; SITACT = SIT with active recovery periods between 4 bouts; SITPASS = SIT with passive recovery periods between 4 bouts.

shorter exercise and recovery periods (52). Our finding of no difference in PACES between SITPASS and SITACT adds to the body of work examining enjoyment during SIT and indicates that active versus passive recovery format during SIT is not a key determinant of enjoyment. This is expected to be contributed to by the similarity of physiological and perceived intensity responses during the 2 SIT conditions, evidenced by the lack of difference in HR and RPE. This is despite the difference in overall work found between the conditions (largely because of the addition of 3 × 2 min of cycling at 60 Watts during the active recovery periods of SITACT). Additionally, more well-designed research taking into account the effect of exercise mode on enjoyment is needed, but this was beyond the scope of the current study.

The finding of no difference in PACES between REC and the SIT conditions is unexpected as REC represented very-low-intensity intermittent exercise while the SIT conditions represented very-high-intensity exercise, as illustrated by the differences in HR and $\mathrm{RPE}^{\mathrm{COND}}$. Additionally, the mean PACES scores for all 3 conditions (SITPASS = 74, SITACT = 82, and REC = 77) were substantially lower than those reported in other SIT research in sedentary or inactive populations (≥ 91) (12,53,54). The inactive individuals participating in this experiment expressed low levels of exercise enjoyment regardless of the exercise intensity or recovery format. This indicates that the participants found exercise, in general, relatively unenjoyable and could be a potential contributing factor to their current inactive status. These findings, taken together, therefore do not support previous suggestions that the adoption of SIT may be a solution to widespread insufficient physical activity behaviors, solely because of the appeal of time efficiency embodied by this format of exercise (27,55).

Blood Pressure

During SIT, SBP did not reach recommended values that would warrant exercise termination in any participants (250 mm Hg) (56). Furthermore, the mean maximal SBP values achieved by the participants as illustrated in Figure 4 (164 mm Hg after the fourth bout of SITPASS) would not be considered an acute hypertensive or exaggerated response to maximal or peak exercise (90th–95th percentile of exercise BP ≥ 210 mm Hg in males), which is associated with various markers of cardiovascular disease risk and increased mortality risk (31–33). However, it is noted that the somewhat heterogenous thresholds that define a hypertensive or exaggerated response to exercise have been ascertained during incremental exercise, not SIT, and that more research is needed to make definitive conclusions regarding exaggerated exercise BP thresholds (33).

No differences were found for SBP when comparing SITPASS and SITACT. The SBP responses were therefore not affected by recovery format, possibly because of the integratory physiological control mechanisms that ensured SBP remained within normal ranges throughout exercise and recovery (37). Furthermore, the similar SBP and HR responses between SITPASS and SITACT likely reflect similar levels of cardiovascular strain during exercise and that any differences between the recovery formats were abolished at the onset of each bout.

Together these findings indicate that the acute SBP response to this format of exercise was largely appropriate and safe in this sample of young inactive individuals, consistent with previous high-intensity interval research in young physically active individuals, which measured peak BP response using the same method and timing as the current study (57).

The accepted DBP response to continuous or incremental exercise is a slight decrease or no change (28). Our findings during the SIT conditions indicate a similar response during high-intensity intermittent exercise, with no statistically significant decrease in DBP occurring during the exercise component of the SIT conditions, compared with resting DBP. However, during the 6-min passive recovery period postexercise, a decline in DBP was observed during both SIT protocols, possibly because of peripheral vasodilation (and hence a decrease in total peripheral resistance) (58,59) and/or postexercise hyperemia in response to the high-intensity exercise conditions (60). The DBP during SITACT reached a minimum after 2 min of recovery, before returning to near resting levels by 6 min postexercise. The minimum DBP recorded during SITPASS was reached 6 min after exercise cessation. The continued reduction in postexercise DBP following SITPASS is consistent with the DBP response during passive postexercise recovery following SIT research in which similar BP measurement timings were used (7,59,61,62). At 6 min postexercise, DBP was significantly lower in SITPASS, compared with resting levels, and compared with SITACT and REC. Additionally, while differences in MAP did not achieve significance between protocols, it is noted that mean MAP tended to be lower at 6 min postexercise after SITPASS (81 mm Hg), compared with SITACT (86 mm Hg) and REC (89 mm Hg). While it is beyond the scope of this study to determine the physiological mechanisms contributing to the reduction in DBP during the recovery portion of SITPASS, this could be attributed to the combination of an upright posture, the absence of the secondary muscle pump, blunted reflex vasoconstrictor responses or cardiovagal baroreflex sensitivity, and the dilation of the peripheral vasculature (36,60,62). In comparison, the active recovery portions of SITACT (via muscle pump contributions to venous return and cardiac output) potentially compensated for the persistent decrease in peripheral vascular resistance during recovery, allowing a relatively rapid return to pre-exercise DBP levels.

The decrease in DBP postexercise coincided with presyncopal symptoms of dizziness and/or nausea in 6 participants (3 after SITPASS, 2 after SITACT, and 1 after both conditions), which resolved with extended recovery time. Furthermore, the mean reduction in DBP (resting DBP compared with DBP 6 min postexercise) was larger in the symptomatic participants (mean = 11 mm Hg) than in the asymptomatic participants (mean = 6 mm Hg), regardless of whether the participants were performing passive or active recovery between exercise bouts. MAP at 6 min postexercise, regardless of recovery condition, was also lower for symptomatic versus asymptomatic participants (mean = 77 mm Hg versus 92 mm Hg respectively). While it is important to interpret these observations with caution as causation cannot be established, rates of presyncope can be over 50% during high-intensity exercise interventions investigating postexercise syncope (60). Participants have been known to experience vasovagal events after SIT (34), and participation in high-intensity interval training can increase the risk of falls (63). Therefore, given the reductions in DBP postexercise and the concomitant presyncopal symptoms reported by half of the participants, it seems prudent to suggest an increased surveillance of postexercise BP and relevant signs and symptoms in inactive individuals if individuals cannot perform active postexercise recovery due to fatigue, which is likely after exhaustive SIT exercise in inactive individuals (37). However, in individuals not prone to symptomatic PEH, the decreases in DBP after SITPASS could indicate a potential cardiovascular benefit, an acute manifestation of the DBP reductions evidenced in longitudinal high-intensity interval training studies (2) and meta-analysis (64) and could therefore have positive implications for the prevention or treatment of hypertension (34). The investigation of these issues is beyond the scope of the current experiment and is therefore suggested as possible future research directions.

This study has the following limitations. The final BP measurement was taken 6 min after exercise cessation. It is acknowledged that further changes in SBP and/or DBP may have occurred after this point. However, this study was designed to evaluate the acute effects of SIT protocols that included active and passive recovery periods. Therefore, the acute findings of this study provide the basis and justification for future, more prolonged examinations of postexercise BP changes in response to alterations in SIT protocol design parameters. Additionally, participants in this experiment were exclusively men, thereby excluding the influence of potential sex differences in respiratory, hormonal, and energy substrate use factors and allowing for gender-specific exaggerated BP response to exercise thresholds to be applied. The exclusion of women from the participant group, however, limits the generalizability of the research findings and does not allow commentary on the mediating effects of sex on BP and enjoyment during SIT. Taking into consideration that greater numbers of Australian women are insufficiently active, compared to men (65), it is important to investigate sex-specific responses to SIT (66), if SIT is proposed to improve physical activity levels in the community. Therefore, this issue is suggested as an important area for future research.

Controlled experiments that examine the effect of exercise interventions on participants' enjoyment levels have limitations to their validity, as the exercise sessions are prescribed by the researcher and therefore do not allow participants to make choices during the session. Furthermore, by not including a moderate-intensity exercise condition, we were unable to evaluate the participants' perceptual attitudes and enjoyment responses to an intermediate exercise intensity. Therefore, suggestions that the participants' lack of enjoyment of the low-intensity REC condition and the 2 SIT conditions indicates a lack of enjoyment of exercise is subject to this caveat.

CONCLUSIONS

It is concluded that in inactive participants, exercise enjoyment and acute SBP responses were independent of SIT recovery format. Acute reductions in DBP were greater and more prolonged after SIT protocols that included passive recovery periods.

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