Reducing training frequency from 3 or 4 sessions/week to 2 sessions/week does not attenuate improvements in maximal aerobic capacity with reduced-exertion high-intensity interval training (REHIT)

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ABSTRACT

In the present randomised-controlled trial we investigated the effect of REHIT training frequency (2/3/4 sessions/week for 6 weeks) on maximal aerobic capacity ($\dot{V}O_2max$) in 42 inactive individuals (13 women; mean±SD age: 25±5 y, $\dot{V}O_2max$: 35±5 mL·kg^{-1}·min^{-1}). Changes in $\dot{V}O_2max$ were not significantly different between the three groups (2 sessions/week: +10.2%; 3 sessions/week: +8.1%; 4 sessions per week: +7.3%). In conclusion, a training frequency of 2 sessions/week is sufficient for REHIT to improve $\dot{V}O_2max$.

- We demonstrate that reducing REHIT training frequency from 3 or 4 to 2 sessions/week does not attenuate improvements in the key health marker of $\dot{V}O_2max$.

Key words:

$\dot{V}O_2max$; sprint interval training; SIT; Wingate sprint; exercise; health

INTRODUCTION

As perceived lack of time is commonly reported as a barrier to exercise (Trost et al. 2002), there is a need to identify time-efficient exercise interventions for reducing the risk of inactivity-related noncommunicable diseases. Sprint interval training (SIT; repeated 'all-out' sprints of 20-30 s) aims to provide a time-efficient alternative to moderate-intensity continuous training (MICT) (Vollaard & Metcalfe 2017), but the total training time commitment of the 'classic' SIT protocol (4-6 x 30-s 'all-out' sprints (Burgomaster et al. 2005)) is greater than that of American recommendations for vigorous exercise (~90 min/week vs. 75 min/week (Garber et al. 2011)). It has previously been shown that the training time commitment of the classic SIT protocol can be substantially reduced while remaining efficacious at improving key health markers such as maximal aerobic capacity ($\dot{V}O_2$max), insulin sensitivity and blood pressure (Gillen et al. 2016; Metcalfe et al. 2012; Ruffino et al. 2017). The reduced-exertion high-intensity interval training (REHIT) protocol (Metcalfe et al. 2012) consists of two 20-second 'all-out' sprints within an otherwise low-intensity 10-minute exercise session.

As long as the associated health benefits are not affected, reducing the total volume of sprint exercise in a SIT protocol could be expected to enhance the uptake of, and adherence to, SIT (Reljic et al. 2019). Reducing sprint duration only has a small effect on overall training time requirement, and we have previously demonstrated that, in the REHIT protocol, performing 10-second 'all-out' sprints is less effective at improving $\dot{V}O_2$max compared to 20-second sprints (Nalcakan et al. 2018). Conversely, reducing the number of sprint repetitions in a SIT session has a large effect on overall training time-commitment, as this also reduces the number of relatively lengthy recovery periods. In a recent meta-analysis, we demonstrated that performing as few as 2 sprint repetitions within a SIT session is sufficient for improving $\dot{V}O_2$max, with no apparent added benefit of performing additional sprints (Vollaard et al. 2017).

Apart from sprint duration and number of sprint repetitions, a final approach to reducing the total volume of sprint exercise in a SIT protocol is to reduce the training frequency. A small number of studies investigating the effects of repeated sprint training (RST; repeated 'all-out' sprints of <20 s) (Adamson et al. 2014) and high-intensity interval training (HIIT; repeated (sub-)maximal sprints of ≥60 s) (Stavrinou et al. 2018) have demonstrated significant improvements in $\dot{V}O_2$max with just 2 training sessions/week for 8 weeks, but to the best of our knowledge, the effect of training frequency on improvements in $\dot{V}O_2$max in response to SIT has not yet been studied. Similar to REHIT, most commonly studied SIT protocols involve a training frequency of 3 sessions/week (Vollaard et al. 2017). It is possible that a lower training frequency would enhance uptake of, and adherence to, an exercise routine. Conversely, a higher training frequency could be expected to result in greater improvements in key cardiometabolic health markers. Thus, the aim of the present study was to determine the effect of training frequency (2, 3 or 4 sessions/week) on changes in $\dot{V}O_2$max in response to 6 weeks of REHIT in inactive individuals. We hypothesised that a greater training frequency would increase the magnitude of adaptations, with the greatest improvements with a training frequency of 4 sessions/week.

MATERIALS AND METHODS

Participants

Apparently healthy, inactive participants were recruited at 4 sites in the UK (Derry/Londonderry, Stirling, Swansea, Worcester), and randomised into groups performing the REHIT protocol as previously described by Metcalfe et al. (2012), but involving either 2 (REHIT2), 3 (REHIT3) or 4 (REHIT4) training sessions per week. Randomisation was performed using the sealed envelope method. Exclusion criteria were classification as highly physically active according to the International Physical Activity Questionnaire (IPAQ), contraindications to exercise as determined using a standard physical activity readiness questionnaire (PAR-Q), clinically significant hypertension (>140/90 mm Hg), or resting heart rate ≥100 beats·min^{-1}. Forty-nine participants volunteered to take part, but 7 participants dropped out of the study (REHIT3: n=3 (reasons: lack of time for all); REHIT4: n=4 (unrelated medical issue, pregnancy, lack of time)). Characteristics of the remaining participants are shown in **Supplementary Table S1** (Worcester: n=18, Stirling: n=9, Swansea: n=9, Ulster: n=6). Participants were asked not to change their normal diet and/or physical activity patterns for the duration of the study. The study received University Ethics approval (NICR(17/18-16); 2016-111). All participants provided written consent after full written and verbal explanation of the study protocol.

Experimental Procedures

An incremental cycling test to exhaustion was used to determine $\dot{V}O_2$max (Excalibur Sport, Lode, Groningen, the Netherlands; CV: ~4%). An online gas analyser was used to measure oxygen uptake (Oxycon Pro, Jaeger; Jaegar Vyntus, Vyaire Medical Products; Cortex Metalyzer, Cortex; Quark C-PET, Cosmed). Participants were requested not to perform strenuous exercise and/or to consume caffeine or alcohol on the day prior to testing, and to drink a pint of water in the morning before testing. The test started with a 5-min warm-up (50 W), after which the intensity was increased by 1 W every 3 s until volitional exhaustion. $\dot{V}O_2$max was determined as the highest value of a 15-breath rolling average, and accepted if ≥2 of the following criteria were met: 1) volitional exhaustion, 2) RER>1.15, and 3) maximal heart rate within 10 beats of the age-predicted maximum (i.e. 220-age). This was the case for all participants.

Participants subsequently performed six weeks of REHIT consisting of 2, 3 or 4 exercise sessions per week. REHIT sessions involved 10 min of unloaded cycling interspersed with 2 all-out sprints against a resistance of 7.5% of the participant's body mass (Ergomedic 874e, Monark, Sweden). Sprint duration was 10 s in week 1, 15 s in week 2, and 20 s in the remaining 4 weeks. The first sprint finished at 2 min and the second sprint finished at 7 min. A questionnaire on the acceptability of the intervention (Boereboom et al. 2016) was completed after the last exercise session. The post-training $\dot{V}O_2$max test was scheduled 3 days following the last training session. Data on RPE and acute changes in affect in response to REHIT training sessions was collected, but this data is presented in a previous publication (Songsorn et al. 2019).

Statistical analysis

Data are presented as mean±SD. To detect differences in the change in $\dot{V}O_2$max between the three groups with an effect size of f=0.5, power of 80% and α=0.05, at least 12 participants were required in each group. Two-way mixed model ANOVA (group (REHIT2/REHIT3/REHIT4)) × time (pre/post)) was used to determine differences between the groups for $\Delta\dot{V}O_2$max and for Δbody mass. A Kruskal-Wallis H test was used to determine differences between the three groups for intervention acceptability. Significance was accepted at $p<0.05$.

RESULTS

Overall mean adherence (% of prescribed training sessions completed) was not significantly different between the three groups (99% for REHIT2, 98% for REHIT3, 99% for REHIT4). No significant changes from pre- to post-intervention were observed for body mass (REHIT2: 84.5±20.7 vs. 84.5±20.6 kg; REHIT3: 70.6±15.9 vs. 71.1±16.0 kg; REHIT4: 79.3±7.8 vs. 78.8±7.3 kg). There was a significant improvement in absolute $\dot{V}O_2max$ (+8.7%; main effect of time: $p<0.001$), but no significant group*time interaction effect, indicating similar improvements in the 3 groups (REHIT2: +10.2%, REHIT3: +8.1%, REHIT 4: +7.3%; **Figure 1**).

Acceptability of the 3 REHIT interventions was good (**Supplementary Table S2**). On average, participants' responses indicated that they thought REHIT was enjoyable, that is wasn't a time-burden, that the physical strain and traveling involved with REHIT did not interfere with their life, that they would continue doing REHIT, and that they would recommend REHIT to others. Participants did tend towards agreeing that REHIT was more demanding than expected. There were no significant differences between the 3 groups for any of the responses.

DISCUSSION

To date the vast majority of studied SIT protocols have used a training frequency of 3 sessions/week, but to the best of our knowledge, no papers have studied if, or justified why, this would be the 'optimal' training frequency (e.g. either the lowest training volume to achieve a given mean improvement in $\dot{V}O_2max$, or the training dose with the greatest mean improvement in $\dot{V}O_2max$). Thus, the present study aimed to determine the effect of training frequency (2, 3 or 4 sessions/week) on changes in $\dot{V}O_2max$ in response to 6 weeks of REHIT in inactive individuals. For the first time, we demonstrate that performing 2 REHIT sessions per week for 6 weeks is sufficient to significantly improve $\dot{V}O_2max$, and that performing 3 or 4 sessions/week does not significantly augment the magnitude of improvement. Thus, similar to the number of sprints within a SIT session (Vollaard et al. 2017), the total volume of sprint exercise per week does not appear to be a main driver of adaptations to $\dot{V}O_2max$ for SIT. This finding is important, because lack of time is commonly reported as a barrier to exercise (Kimm et al. 2006; Korkiakangas et al. 2009; Trost et al. 2002), and reducing the number of training sessions per week from 3 to 2 has a large effect on the total required time commitment.

The lack of a significantly greater improvement in $\dot{V}O_2max$ with 3 or 4 REHIT sessions/week compared to 2 sessions/week is contrary to our hypothesis. A greater training volume is generally expected to enhance adaptations (Church et al. 2007), but it appears that a low dose of REHIT (2 sessions/week) is sufficient to stimulate the mechanisms by which REHIT induces improvements in $\dot{V}O_2max$ to a similar extent as with higher doses (3 or 4 sessions/week). Some support for our finding comes from a recent study by Stavrinou et al. (2019), who reported that improvements in $\dot{V}O_2max$ with twice-weekly HIIT (10 x 60 s cycling at ~83% of peak power) are not significantly different from those with the same protocol performed three times/week.

It remains unknown whether greater training frequencies (>4 sessions/week) could increase the magnitude of improvements in $\dot{V}O_2max$, or whether a lower training frequency (1 session/week) would be sufficient. This will need to be established in future studies.

There are a number of limitations to our study that need to be highlighted. Firstly, although we did not observe a significant *difference* in the magnitude of improvements in $\dot{V}O_2max$ between REHIT protocols performed 2, 3 or 4 times/week, the study was not powered to test for statistical *equivalence* of the improvements. Secondly, we did not stratify the groups in any way, so we cannot exclude potential confounding effects of for example sex or baseline $\dot{V}O_2max$, nor can we exclude a possible confounding effect through the use of different gas analysers in our multi-centre approach. Thirdly, we only studied the effect of training frequency on changes in $\dot{V}O_2max$, so it remains unknown whether training frequency may affect adaptations for other important health markers such as blood pressure, insulin sensitivity, or body composition.

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Conflicts of Interest

The authors have no conflicts of interest to report.

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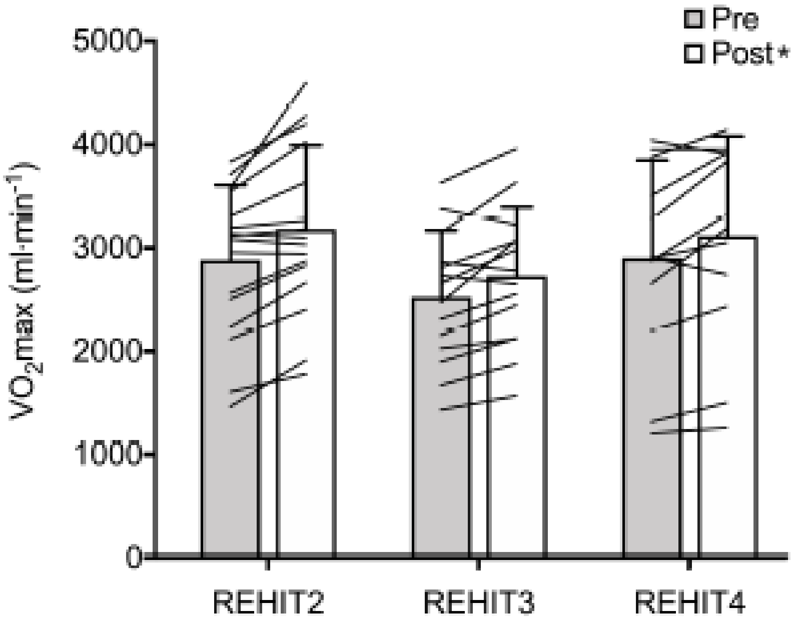
Figure 1 Changes in $\dot{V}O_2$max in response to 6 weeks of REHIT performed at a training frequency of 2, 3 or 4 sessions per week. There was no significant difference between the 3 groups for the training-induced change in $\dot{V}O_2$max.



Supplementary Table S1 Participant characteristics

	REHIT2 2 sessions/week (n=16)	REHIT3 3 sessions/week (n=14)	REHIT4 4sessions/week (n=12)
Sex (male / female)	12 / 4	8 / 6	9 / 3
Age (y)	26±6	26±5	24±4
BMI (kg·m^{-2})	27.1±4.6	24.3±4.2	26.9±2.4
Baseline $\dot{V}O_2$max (mL·kg^{-1}·min^{-1})	34.4±6.1	35.7±4.8	36.2±4.8
Physical activity level (MET-min·week^{-1})	425±269	565±316	541±307

Values shown are means±SD. Physical activity level was estimated using the IPAQ.

Supplementary Table S2 Acceptability of REHIT

	REHIT2 2 sessions/week (n=16)	REHIT3 3 sessions/week (n=14)	REHIT4 4 sessions/week (n=12)
I enjoyed REHIT	1.6±0.5	1.6±0.8	1.9±0.7
REHIT was a time burden	3.9±1.2	3.9±1.1	3.6±1.1
I would recommend REHIT to others	1.5±0.6	1.4±0.5	1.9±0.5
REHIT was more demanding than expected	2.6±1.1	2.4±0.8	2.9±1.2
I would do REHIT again	1.6±0.5	1.4±0.6	2.1±0.9
The travelling involved with REHIT interfered with my life	4.0±1.2	3.9±1.2	3.6±1.4
The physical strain interfered with my life	4.7±0.5	4.6±0.6	4.0±0.9
I believe my fitness has improved	1.8±0.8	1.9±0.8	1.8±0.5

Values shown are means±SD. Responses are given on a 5-point Likert scale ranging from 1 (strongly agree) to 5 (strongly disagree).