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BRIEF COMMUNICATION

Do stair climbing exercise "snacks" improve cardiorespiratory fitness?

E. Madison Jenkins, Leah N. Nairn, Lauren E. Skelly, Jonathan P. Little, and Martin J. Gibala

Abstract: We investigated the effect of stair climbing exercise "snacks" on peak oxygen uptake. Sedentary young adults were randomly assigned to perform 3 bouts/day of vigorously ascending a 3-flight stairwell (60 steps), separated by 1–4 h of recovery, 3 days/week for 6 weeks, or a nontraining control group (n = 12 each). Peak oxygen uptake was higher in the climbers after the intervention (P = 0.003), suggesting that stair climbing "snacks" are effective in improving cardiorespiratory fitness, although the absolute increase was modest.

Key words: sprint interval training, peak oxygen uptake.

Résumé : Nous étudions l'effet des exercices courts et rapides de montée d'escaliers sur la consommation d'oxygène de pointe. De jeunes adultes sédentaires sont répartis de façon aléatoire dans un groupe expérimental pour effectuer trois séances/jour de montées vigoureuses dans une cage d'escalier à trois volées (60 marches), intercalées de 1–4 h de récupération, 3 jours/semaine pendant 6 semaines ou à un groupe de contrôle sans entraînement (n = 12 chacun). La consommation d'oxygène de pointe est plus élevé chez les monteurs d'escalier après l'intervention (P = 0,003), ce qui suggère que les montées brèves et rapides des escaliers sont efficaces pour améliorer la condition cardiorespiratoire, bien que l'augmentation absolue soit modeste. [Traduit par la Rédaction]

Mots-clés : entraînement par intervalles de sprint, consommation d'oxygène de pointe.

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Introduction

Low cardiorespiratory fitness (CRF) is associated with an increased risk of all-cause mortality and cardiovascular disease (Kodama et al. 2009). Habitual physical activity increases CRF but many individuals do not perform sufficient amounts as recommended by public health agencies, often citing "lack of time" as a perceived barrier (Colley et al. 2011). Sprint interval training (SIT), involving brief bouts of vigorous exercise interspersed with 2 min of recovery, increases CRF similar to traditional moderate-intensity continuous training despite reduced time commitment (Gillen et al. 2016; Gist et al. 2014). Most SIT studies involve specialized equipment and protocols that are not easily transferable outside of a laboratory setting. Vigorous stair climbing is a practical and accessible form of SIT that can increase CRF in previously sedentary individuals when performed for several weeks (Allison et al. 2017).

Francois et al. (2014) coined the term "exercise snacks" to describe breaking up a single session of continuous exercise into several shorter bouts spread throughout the day. A training program involving three ~12-min bouts of intermittent interval exercise was superior to a single daily bout of energy-matched continuous exercise for improving blood sugar control in people with insulin resistance (Francois et al. 2014). It is unknown if SIT exercise snacks, or brief bouts of vigorous exercise performed as single sprints spread throughout the day, is a sufficient stimulus to improve CRF. The design of the present study was modelled after work by Allison et al. (2017); however, in contrast to the original protocol, the 3 bouts of stair climbing were separated by a few hours of recovery, as compared with being performed in a single session with a few minutes in between bouts. We hypothesized that, as compared with a nontraining control group, a protocol involving 3 daily bouts of vigorously ascending a 3-flight stairwell (60 steps), with 1–4 h recovery, would enhance CRF when performed 3 days/week for 6 weeks.

Materials and methods

Participants

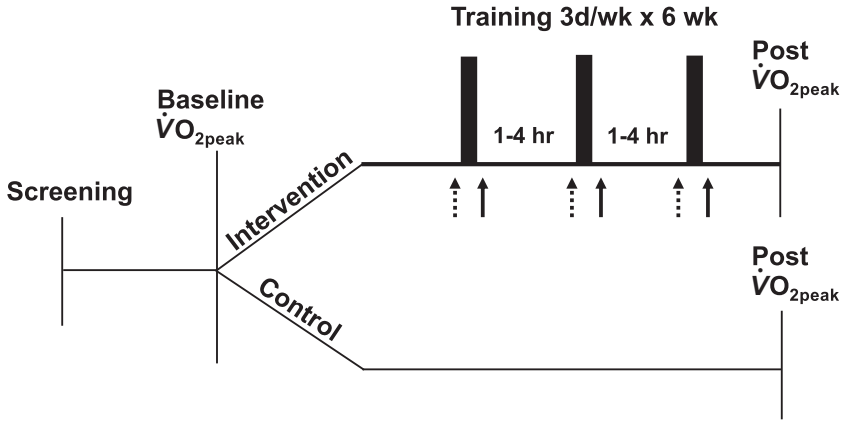
Twenty-four young adults were recruited primarily from the student population at McMaster University. Inclusion criteria were deemed healthy based on the Canadian Society for Exercise Physiology (CSEP) General Activity Questionnaire (GAQ) (CSEP 2017) and inactive as determined by a self-report of less than 1 h of structured physical activity per week using the International Physical Activity Questionnaire (Craig et al. 2003). Exclusion criteria were: diagnosed cardiometabolic disease, smoker, and answering "yes" to any of the questions on the GAQ form. Participants were assigned to either the stair-climbing intervention (n = 12; male/female = 3/9, age = 20.0 ± 1.8 years; body mass index = 21.9 ± 5.0 kg/m^2; mean ± SD) or a nontraining control group (n = 12; male/female = 2/10, age = 19.3 ± 1.6 years; body mass index = 23.8 ± 2.6 kg/m^2) using a block randomization scheme and block size of 2 to ensure an equal number of subjects in each group. Participants assigned to the control group were given the option to complete the exercise intervention following the main

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E.M. Jenkins, L.N. Nairn, L.E. Skelly, and M.J. Gibala.* Department of Kinesiology, McMaster University, Hamilton, ON L8S 4K1, Canada.
J.P. Little.* School of Health and Exercise Science, University of British Columbia, Kelowna, BC V1V 1V7, Canada.
Corresponding author: Martin J. Gibala (email: gibalam@mcmaster.ca).
*Martin J. Gibala and Jonathan P. Little currently serve as Associated Editors; peer review and editorial decisions regarding this manuscript were handled by Philip Atherton and Terry E. Graham.

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Fig. 1. Study design. Vertical bar represents 1 ascent up a 3-flight stairwell (60 steps). Dashed arrow represent warm-up, solid arrow represent cool-down. $\dot{V}O_{2peak}$, peak oxygen uptake.



study. The protocol was approved by the McMaster Research Ethics Board, and all participants provided written informed consent after being advised of the experimental procedures and potential risks.

Experimental protocol

Participants initially reported to the laboratory for a determination of peak oxygen uptake ($\dot{V}O_{2peak}$) and peak power output (W_{peak}) based on a ramp exercise protocol performed on a cycle ergometer (Excalibur Sport, version 2.0; Lode BV, Groningen, the Netherlands) and metabolic cart with an online gas collection system (Moxus; AEI Technologies, Pittsburgh, Pa., USA) as previously described (Allison et al. 2017). Briefly, after a 3-min warm-up at 50 W, power output increased by 1 W every 2 s until the pedal cadence fell less than 60 rpm. Method error reproducibility for the $\dot{V}O_{2peak}$ test (coefficient of variation) was 2% with an intraclass correlation coefficient of 98.6% when assessed using 2 baseline tests performed ~1 week apart in 13 participants.

The participants in the intervention group subsequently returned to the laboratory and practiced the stair climbing protocol by completing a single bout of the 3-flight stair case. Participants were also familiarized with wearing the heart rate monitor and using the rating of perceived exertion scale. Training was commenced ≥72 h after the familiarization session. Participants reported to the staircase 3 times per day, 3 days a week, for a total of 54 training sessions over 6 weeks. The stair climbing protocol was modeled after previous work in our laboratory (Allison et al. 2017) that involved 3×20-s "all-out" sprints interspersed with 2 min of recovery, such that 58 ± 4 stairs were climbed per bout and a total of 180 ± 11 stairs per session. For the present study, each "exercise snack" involved a continuous ascent of a 3-flight (60-step) stair case. Each session was supervised by a member of our research group, and subjects were instructed to "safely ascend the stairs, 1 step at a time, as quickly as possible using the railings as deemed necessary for support." Three bouts were performed each day, separated by a minimum of 1 h and maximum of 4 h. Each bout was preceded by a dynamic warm-up consisting of 10 jumping-jacks, 10 air squats, and 5 lunges on each side, and followed by a cool-down consisting of 1 min of level walking. Participants reported their rating of perceived exertion (RPE) using the Borg category ratio scale (0–10) immediately before and after each bout and heart rate was measured periodically during training sessions to monitor relative effort and training intensity. Post-training measurements of $\dot{V}O_{2peak}$ and W_{peak} were performed ~72 h after the last training session. Subjects in the control group returned for an additional round of testing 6 weeks after their baseline tests (Fig. 1).

Statistical analysis

$\dot{V}O_{2peak}$ and W_{peak} data were analyzed using analysis of covariance (ANCOVA) with the pretest utilized as a covariate in the model (Rausch et al. 2003). Statistical significance was set as $P \leq 0.05$. Cohen's d was used to determine effect size for the change from pre- to post-training in the intervention group. Data are presented as means ± SD ($n = 12$ for each group, except $n = 11$ for $\dot{V}O_{2peak}$ for control group owing to removal of 1 subject identified as a statistical outlier, >2 SD below mean). Training characteristics (RPE, heart rate (HR), time to ascend) were analyzed using a 1-way ANOVA.

Results

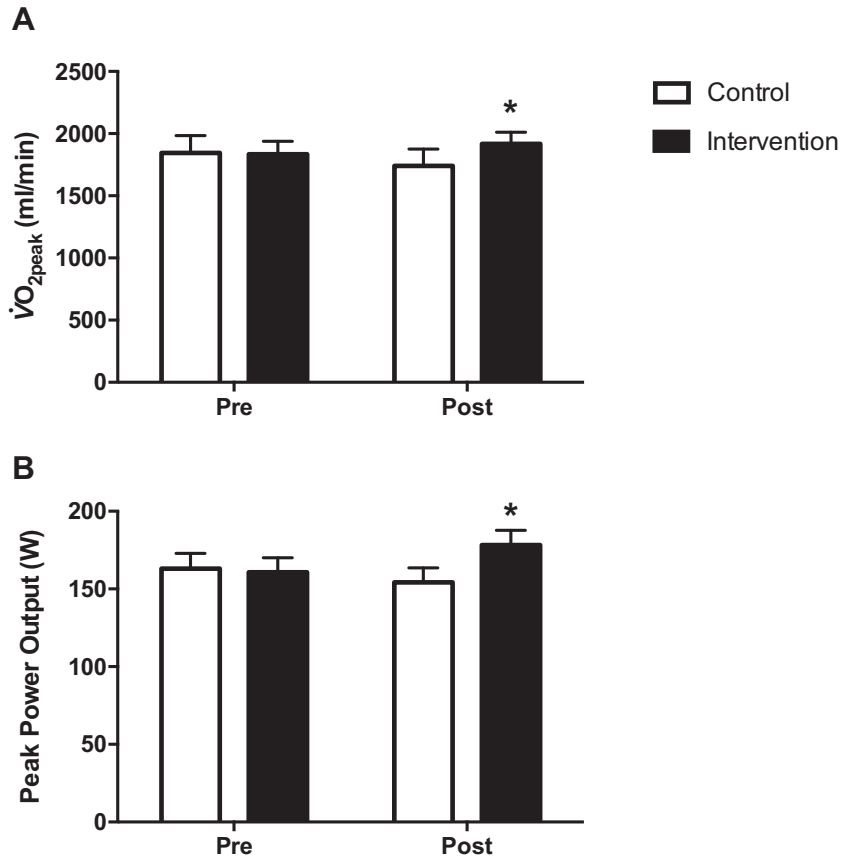
At baseline, $\dot{V}O_{2peak}$ in both groups was similar (1834 ± 363 vs. 1844 ± 467 mL/min). ANCOVA revealed a significant ($P = 0.002$) difference between groups after the intervention, such that $\dot{V}O_{2peak}$ was higher in the training group compared with control, 1918 ± 326 and 1740 ± 453 (mL/min), respectively (Fig. 2A), and the corresponding effect size was $d = 0.46$. However, the absolute increase in $\dot{V}O_{2peak}$ in the training group compared with baseline was modest (~5% increase, 95% confidence interval (CI): 15, 164 mL/min). Baseline W_{peak} was also similar between groups at baseline (161 ± 33 vs. 163 ± 34 W). W_{peak} was also higher ($P < 0.001$) in the training group compared with control after the intervention, 178 ± 32 and 154 ± 33 (W), respectively (Fig. 2B), and the corresponding effect size was $d = 0.74$. The absolute increase in W_{peak} in the training group compared with baseline was 12% (95% CI: 6, 34 W). With respect to characteristics during training, mean RPE was similar throughout training and corresponded to 5 ± 1 or a value of "hard". Mean HR was also relatively consistent during training (169 ± 12 and 174 ± 14 bpm, respectively, during weeks 1 and 6, $P = 0.50$) and corresponded to ~85% of age-predicted maximum. Mean time to ascend 60 steps generally decreased across the training period, with a significant decrease in time of ascent from week 1 to week 6, 22 ± 3 and 20 ± 2 s, respectively ($P = 0.001$). The 12 participants in the training intervention completed all scheduled training sessions.

Discussion

This was the first study to investigate the effect of brief bouts of stair climbing exercise spread throughout the day on CRF. Performing 6 weeks of sprint exercise snacks with 1–4 h rest in between bouts resulted in a higher $\dot{V}O_{2peak}$ when compared with a nonexercise control group. We also found that W_{peak} was higher in the training group compared with control, suggesting a beneficial effect of the stair climbing protocol on this measure of functional capacity.

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Fig. 2. Absolute peak oxygen uptake ($\dot{V}O_{2peak}$) (A) and peak power output (B) measured before (Pre) and after (Post) 6 weeks of stair climbing sessions or an equivalent period without a prescribed exercise intervention. Values are means ± SD. *, $P < 0.05$ between groups.



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The stair climbing protocol in the present study was modelled after previous work in our laboratory (Allison et al. 2017), with the key difference being the duration of recovery between exercise bouts. The improvement in $\dot{V}O_{2peak}$ in the present study (~5%) was relatively smaller than observed in our previous study (Allison et al. 2017), in which bouts of intermittent stair climbing were performed with a few minutes of recovery periods (~12%). We attribute this smaller relative improvement in $\dot{V}O_{2peak}$ to the longer period of recovery between stair climbing bouts, i.e., 1–4 h (mean 2.4 ± 1.3 h) in the present study as compared with 2 min in our previous study (Allison et al. 2017). In support of this interpretation, mean RPE remained consistent across bouts of exercise in the present study, whereas in the work of Allison et al. (2017), RPE climbed over the course of the successive bouts, suggesting a greater relative stress when recovery periods are short and the stair climbing bouts are performed as a single training session.

Despite eliciting relatively smaller improvements in $\dot{V}O_{2peak}$ as compared with our previous study that used brief recovery periods (Allison et al. 2017), the improvements in W_{peak} were similar, suggesting less of an effect of recovery duration on the determinants of this measures. It is possible that the intense stair climbing efforts provided a greater stimulus for peripheral (i.e., skeletal muscle) adaptations, which contributing to the improved W_{peak}. It is also possible that the nature of the warm-up exercise, while brief, may have contributed to a leg-strengthening effect. The improvements in cycling W_{peak} occurred despite the training being performed as stair climbing, suggesting that overall exercise tolerance and capacity was improved.

Some limitations are to be addressed in our study: first, we did not employ a blinded randomization procedure, and a randomization concealment tool would have eliminated any potential bias introduced during this process. Another potential limitation is that while subjects were instructed to maintain their habitual living patterns it is possible that changes in behaviour (e.g., physical activity) could have influenced the measurement of $\dot{V}O_{2peak}$.

In conclusion, the stair climbing exercise snacking protocol tested in this study resulted in a 5% increase in CRF and 12% increase in cycling peak power output in healthy, sedentary adults, which was significantly higher when compared with a nontraining control group. The absolute increase in CRF was modest, however, and relatively smaller than we previously observed when a similar stair-climbing intervention was performed as a single session with a few minutes of recovery between bouts, as compared with the 1–4 h of recovery between bouts in the present study. We speculate that the longer recovery periods may reduce the overall metabolic stress as compared with traditional sprint interval training protocols and potentially attenuate the adaptive response in CRF. The present work nonetheless shows that the stair climbing exercise snacking protocol was feasible, and well-tolerated by sedentary individuals, and improved functional performance. Future research should investigate different exercise snacking protocols with varying recovery time to determine whether the increased time between snacks attenuates the metabolic stress characteristic of SIT and changes in CRF. Additionally, future research should examine the effect on other-health related indices such as blood pressure and glycemic control.

Conflict of interest statement

All authors report no conflicts of interest.

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