Training effects of short bouts of stair climbing on cardiorespiratory fitness, blood lipids, and homocysteine in sedentary young women

C A G Boreham, R A Kennedy, M H Murphy, M Tully, W F M Wallace, I Young

Objectives: To study the training effects of eight weeks of stair climbing on VO2MAX, blood lipids, and homocysteine in sedentary, but otherwise healthy young women.

Methods: Fifteen women (mean (SD) age 18.8 (0.7) years) were randomly assigned to control (n = 7) or stair climbing (n = 8) groups. Stair climbing was progressively increased from one ascent a day in week 1 to five ascents a day in weeks 7 and 8. Training took place five days a week on a public access staircase (199 steps), at a stepping rate of 90 steps a minute. Each ascent took about two minutes to complete. Subjects agreed not to change their diet or lifestyle over the experimental period.

Results: Relative to controls, the stair climbing group displayed a 17.1% increase in VO2MAX and a 7.7% reduction in low density lipoprotein cholesterol (p < 0.05) over the training period. No change occurred in total cholesterol, high density lipoprotein cholesterol, triglycerides, or homocysteine.

Conclusions: The study confirms that accumulating short bouts of stair climbing activity throughout the day can favourably alter important cardiovascular risk factors in previously sedentary young women. Such exercise may be easily incorporated into the working day and therefore should be promoted by public health guidelines.

Physical activity is now well established as a key component in the maintenance of good health and disease prevention. Despite this, less than 20% of adults in most developed countries are sufficiently active to derive any discernible health and fitness benefits. Furthermore, it has been hypothesised that increasing physical activity in previously sedentary people may prove the most effective strategy for prevention of cardiovascular disease (CVD) on a population basis.

Current physical activity guidelines recommend that every adult should engage in 30 minutes or more of moderate intensity physical activity on most, preferably all, days of the week. One strategy advocated to meet this activity goal is to accumulate exercise in short bouts throughout the day. The efficacy of this approach has been shown experimentally using 10 minute bouts of activity. However, to date only one stair climbing study has shown that accumulating very short bouts of exercise lasting about two minutes can also confer health benefits. Some limitations of this study were that the cardiorespiratory adaptations noted were not determined using maximal oxygen consumption (VO2MAX), and the other CVD risk factors measured were restricted to total cholesterol (TC) and high density lipoprotein cholesterol (HDL-C). Therefore the purpose of this study was to: (a) determine if the previously reported cardiorespiratory adaptations to accumulated bouts of stair climbing could be replicated using direct measurement of VO2MAX; (b) investigate the effects of accumulated bouts of stair climbing on a wider spectrum of CVD risk factors including, TC, HDL-C, low density lipoprotein cholesterol (LDL-C), triglycerides, and homocysteine.

METHODS

Design

This was an eight week intervention study involving previously sedentary young women randomly assigned to stair climbing or control groups after baseline testing. The protocol was approved by the research ethics committee of the Queens University, Belfast, and each participant gave written consent after a full explanation of the procedures and risks involved. Measurements were made at baseline and again after eight weeks of training. All subjects agreed not to change their diet or lifestyle over the experimental period.

Subjects

Volunteers were recruited from the local university undergraduate population through the administration of a self report health and lifestyle questionnaire to 103 female students. Exclusion criteria for volunteers included a history of cardiovascular disease, cigarette smoking, hypertension (systolic/diastolic blood pressure >140/90 mm Hg), diabetes, obesity (body mass index >30 kg/m²), musculoskeletal injury, or the taking of any pharmacotherapeutic drug. Subjects were also required to be sedentary—that is, participation in exercise or sport on one or no occasions each week. Eighteen subjects volunteered to take part in the study, of whom 15 satisfactorily completed the study. Of the three subjects who withdrew from the study, one cited insufficient time, one completed the intervention but failed to complete the testing afterwards, and one developed a medical condition that contraindicated exercise.

Cardiorespiratory fitness

VO2MAX was determined using an incremental test to volitional fatigue on an electronically braked cycle ergometer (Cardiotest 100; Seca, Hamburg, Germany). The test protocol consisted of an initial workload of 40 W, which was increased by 40 W every three minutes, using a pedalling frequency of 60–70 rpm. Heart rate was monitored by a short
wave telemetry system (Vantage NV; Polar Electro, Kempele, Finland). Expired respiratory gases were measured continuously and averaged over 30 second intervals with a Quinton Metabolic Cart (QMC; Quinton, Seattle, Washington, USA).

The oxygen uptake test was considered maximal if at least two of the following criteria were met: heart rate at test termination >85% of age predicted maximum (220 – age), a respiratory exchange ratio at test termination >1.00, or a plateau for VO2 (defined as an increase <2 ml/kg/min despite further increases in workload).

**Anthropometry**

Height and body mass were determined using standard methods. Body mass index was calculated by dividing weight (kg) by height squared (m²).4

**Blood lipids and homocysteine**

Venous blood samples (10 ml) were obtained from an antecubital vein, after a 12 hour overnight fast, with subjects in a seated position and rested for five minutes. Post-intervention samples were obtained 60 hours after the last stair climb to control for any possible transient effects of physical activity on blood lipid concentrations.9 On the day of their pre-intervention blood samples, all subjects were asked to complete a form indicating the stage of their menstrual cycle. Post-intervention blood samples were scheduled for the same stage of each subject’s menstrual cycle, to minimise the potential effects of endogenous hormones on blood lipid concentrations.

Serum TC, triglycerides, and HDL-C were analysed using a Vitros 950 IRC automated analyser (Johnson and Johnson, New Brunswick, New Jersey, USA). The concentration of LDL-C was calculated using the Friedwald formula.10 Total homocysteine was determined by high performance liquid chromatography by previously described methods.11 All samples were assayed in the same batch, within a laboratory subject to external quality control (United Kingdom National Quality Assurance Scheme).

**Exercise prescription**

Subjects allocated to the exercise group embarked on an eight week progressive stair climbing programme. The programme began with two bouts of stair climbing five days a week in weeks 1 and 2, increasing by one climb a day every two weeks. By the last two weeks (7 and 8) of the study, all subjects were completing five bouts of stair climbing five days a week. Subjects climbed in a public access staircase, which consisted of 199 steps with a total vertical displacement of 32.8 m. The prescribed exercise intensity involved climbing the eight flights of stairs at a comfortable but brisk rate (90 steps a minute), determined previously in a stair climbing intervention using these facilities,4 and to descend thereafter at their own pace.

Training logs were kept by all subjects to document the completion of each stair climb. Each bout of stair climbing was integrated into the working day at the convenience of the subject, with a minimum of one hour between climbs. To encourage compliance with the programme and the prescribed intensity of exercise, all stair climbers had supervised sessions once a week. This was supplemented by regular telephone calls, and all subjects were also provided with contact numbers to call if they needed help or information.

**Statistical analysis**

Changes over time were adopted as a summary measure of the response over time for each subject.12 13 Mean changes were compared using an unpaired t test to identify differences in response between groups. The 0.05 level was used as the criterion for statistical significance. The results are given as mean (SD).

**RESULTS**

**Baseline characteristics of the subjects**

Table 1 presents the subjects’ characteristics at baseline. There were no significant differences between groups for any variable.

**Compliance with training**

Compliance in the stair climbing group was good, with a mean 114 (9) (range 97–123) climbs completed out of a possible 130 over the experimental period.

**Training effects of stair climbing**

Table 2 presents the changes in the dependent variables of interest for the groups over the eight week intervention period. There were no significant changes in body mass index, TC, HDL-C, TC/HDL-C ratio, triglycerides, or homocysteine. Relative to controls, the stair climbing group showed a significant increase in VO2MAX and a reduction in LDL-C (p<0.05).

**DISCUSSION**

These findings show that an eight week stair climbing programme characterised by multiple short bouts of vigorous activity can result in positive changes in important CVD risk factors, namely VO2MAX and LDL-C, in a previously sedentary group of young women.

This stair climbing study is the first to show an improvement in cardiorespiratory fitness using direct measurement of VO2MAX.
exercise. Therefore, in today's society when a lack of time is
programme was primarily due to the relatively vigorous
everyday of stair climbing is sufficient to elicit cardiovascular
walking for 36 minutes a day over 24 weeks.25 It appears
physical exercise.27 Of the various lipoproteins, LDL-C is most
favourable changes in circulating lipids induced by regular
programme resulted in similar improvements to VO2MAX as
climbing performed in the final weeks of the eight week
programme. The reduction in LDL-C with no concomitant increase in
lipid profiles, we found a reduction in LDL-C in the exercise
group compared with the control subjects. In part, this was
in homocysteine only in subjects with raised baseline
concentrations, although it was unclear to what extent this
a cardiac rehabilitation programme produced a 12% decrease
in homocysteine after three weeks of strenuous swimming. In
also described more persistent modest increases in homo-
cysteine after three weeks of strenuous swimming. In
the few hours after acute exercise. It is possible that this is
in part due to haemoconcentration. However, Hermann et al37
also described more persistent modest increases in homo-
cysteine after three weeks of strenuous swimming. In
contrast with these studies, Wright et al38 found no effect of
acute exercise.

Decreased homocysteine after an exercise programme
leading to weight loss in overweight women with polycystic
ovary syndrome was described by Randeva et al.39 In addition,
a cardiac rehabilitation programme produced a 12% decrease
in homocysteine only in subjects with raised baseline
concentrations, although it was unclear to what extent this
might have represented regression to the mean.40 It is
possible that exercise intensity may influence homocysteine
responses, although very little work has addressed this;
Vincent et al41 suggested in subgroup analysis that a six
month, high intensity, resistance training programme pro-
duced a small reduction in homocysteine, with a less intense
programme having no effect. The results of our study show
no effect of stair climbing on homocysteine.

Current physical activity guidelines recommend that every
adult should engage in 30 minutes or more of moderate
intensity physical activity on most, preferably all, days of the
week.

Evidence is provided that stair climbing is an efficient,
discrete, and well tolerated way of satisfying the recommend-
ations on physical activity.
hoc calculations suggest that the study only had sufficient power to detect a 1 μmol/l difference in homocysteine change between the intervention and control groups, so it is important not to overinterpret these negative findings.

In conclusion, the results of this randomised, controlled exercise training trial show that short bouts of stair climbing five days a week provide sufficient stimulus to positively exercise training trial show that short bouts of stair climbing in previously sedentary young women. Stair climbing appears to be an efficient, discrete, and well tolerated form of exercise. Furthermore, it requires no specialised facilities or equipment, and is accessible to large sections of industrialised society. Its promotion could have important implications for public health.

Authors’ affiliations
C A G Boreham, R A Kennedy, M H Murphy, Department of Sport and Exercise Science, University of Ulster at Jordanstown, Newtownabbey, Co Antrim, Northern Ireland, UK
M Tully, W F M Wallace, I Young, The Queen’s University of Belfast, Belfast, Northern Ireland, UK
Competing interests: none declared

REFERENCES
Training effects of short bouts of stair climbing on cardiorespiratory fitness, blood lipids, and homocysteine in sedentary young women

C A G Boreham, R A Kennedy, M H Murphy, M Tully, W F M Wallace and I Young

doi: 10.1136/bjsm.2002.001131

These include:

References
This article cites 31 articles, 2 of which you can access for free at:
http://bjsm.bmj.com/content/39/9/590#BIBL

Email alerting service
Receive free email alerts when new articles cite this article. Sign up in the box at the top right corner of the online article.

Notes

To request permissions go to:
http://group.bmj.com/group/rights-licensing/permissions

To order reprints go to:
http://journals.bmj.com/cgi/reprintform

To subscribe to BMJ go to:
http://group.bmj.com/subscribe/