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Effects of single bout of very high-intensity exercise on metabolic health biomarkers in overweight/obese sedentary men

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ABSTRACT

Purpose. This study aimed to investigate the effects of a single session of sprint interval training (SIT) and a single extended sprint (ES), matched for total work, on metabolic health biomarkers.

Methods. Ten overweight/obese men aged 26.9±6.2 years participated. Following a pre-trial incremental exercise test and SIT familiarization, each participant undertook three 2-day trials in randomized order. On Day 1 participants either undertook no exercise (CON), four maximal 30-s sprints, with 4.5 min recovery between each (SIT), or a single maximal extended sprint (ES) matched with SIT for work done. On Day 2, participants had a fasting blood sample taken, undertook an oral glucose tolerance test to determine insulin sensitivity index (ISI), and had blood pressure measured.

Results. Total work done during exercise did not differ between SIT and ES (61.7±2.9 *vs.* 61.3±2.8 kJ; p=0.741). Mean power was higher in SIT than ES (518±21 *vs.* 306±16 W, p<0.0005), resulting in a shorter high-intensity exercise duration in SIT (120±0 *vs.* 198±10 s, p<0.0005). ISI was 44.6% higher following ES than CON (9.4±2.1 *vs.* 6.5±1.3; p=0.022), but did not differ significantly between SIT and CON (6.6±0.9 *vs.* 6.5±1.3; p=0.208). However, on the day following exercise fat oxidation in the fasted state was increased by 63% and 38%, compared to CON, in SIT and ES, respectively (p<0.05 for both), with a concomitant reduction in carbohydrate oxidation (p<0.05).

Conclusion. A single ES, which may represent a more time-efficient alternative to SIT, can increase insulin sensitivity and increase fat oxidation in overweight overweight/obese sedentary men.

Abbreviations: BMI, Body mass index; CON, Control trial; ELISA, Enzyme-linked immunoassay; $HOMA_{IR}$, Homeostasis Model Assessment estimated insulin resistance; ISI, Insulin sensitivity index; OGTT, Oral glucose tolerance test; RER, Respiratory Exchange Ratio; SIT, Sprint interval training; ES, Single extended sprint.

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1. Introduction

The benefits of physical activity in reducing the risk of cardiovascular disease [1,2] and type 2 diabetes [3] have been clearly established. Nevertheless, physical activity levels remain low [4,5], with lack of time often cited as a key barrier to participation [4–6]. As such, interest has grown in time-efficient exercise strategies which reduce the exercise duration required to provide health benefits [7,8].

A number of recent reports have demonstrated that very low volumes of high-intensity exercise in the form of sprint interval training (SIT) – which typically comprises 4–6 30-s cycle ergometer sprints – can induce substantial improvements in both performance [9–11] and health-related [12–15] outcomes. Indices of aerobic (e.g. maximal oxygen uptake, muscle oxidative enzyme activity, time-trial performance and time to fatigue) as well as sprint performance (e.g. peak sprinting power) [9–11,16] have been shown to improve with 2–6 weeks of this type of training. In addition, we [14] and others [12,13,15] have demonstrated that SIT can induce a number of health benefits, including increased insulin sensitivity [12–14], reduced blood pressure [14], and improved vascular function [17]. However, as the beneficial effects of the SIT regime on insulin sensitivity and blood pressure were evident for 24, but not 72, h post-exercise in our study [14], it is unclear whether the observed improvements represented an acute response to the final SIT session or a cumulative, but short-lived, training response to the six session SIT training programme. The first aim of the present study was therefore to address this issue by determining the effects of a single session of SIT on vascular and metabolic risk factors.

It has been proposed that SIT represents a time-efficient approach to obtaining health benefits from exercise, as sessions involve a total of only 2–3 min of high-intensity exercise [18,19]. However, the exercise model used in most SIT studies involve 4 to 6 maximal 30-s sprints on a cycle ergometer, interspersed with 4 to 4.5 min of active recovery between sprints. Thus, SIT sessions still require a total time commitment of 25–30 min, a similar duration to that advocated in conventional physical activity guidelines [20,21]. To determine whether the SIT principle could be adapted into a more time-efficient approach, we sought to investigate whether undertaking a single extended maximal sprint effort (which was matched for the same volume of work done in the 4 × 30-s sprints of an SIT session) could have a similar effect as the SIT protocol on vascular and metabolic risk factors.

2. Methods

2.1. Subjects

Ten men volunteered to participate in this study (age 26.9±6.2 years, height 1.78±0.09 m, body mass 94.2±9.1 kg, BMI 29.9±9.1 kg.m^{-2}, $\dot{V}O_{2peak}$ 42.0±2.4 ml kg^{-1} min^{-1}) (Mean±SD). All participants were aged between 18 and 40 years, were overweight or obese (BMI: 25–35 kg m^{-2}), and all but one subject were participating in less than two hours per week of structured exercise. This group was chosen for study as they represent a population who would benefit from increased activity and who might be particularly targeted for a high-intensity exercise intervention of this nature. Exclusion criteria included uncontrolled hypertension (blood pressure >160/90 mm Hg), previous history of coronary heart disease or family history of early cardiac death (<40 years), and diabetes. All participants provided written informed consent prior to commencing the study which was approved by the University of Glasgow Faculty of Biomedical and Life Sciences Ethics Committee.

2.2. Study design

Following preliminary tests (anthropometry, a Wingate test, a maximal ramp-incremental exercise test, and a preliminary SIT session; all described below), participants performed three main experimental trials in a randomized order, each conducted over two days: a control (CON) trial, an SIT trial and a single extended sprint (ES) trial. Trials were conducted approximately one week apart. On Day 1 participants either: (1) completed four 30 s "all-out" sprint efforts (i.e. repeated Wingate tests) on a cycle ergometer with a 4.5 min active recovery between efforts (SIT); (2) performed a single extended maximal cycle ergometer sprint matched for total work with the familiarization SIT (ES); or (3) performed no exercise (CON). On Day 2, 18–22 h after exercise in the SIT and ES trials, participants attended the laboratory for metabolic testing, comprising assessment of resting metabolic rate and substrate utilization by indirect calorimetry, an oral glucose tolerance test (OGTT) and measurement of blood pressure. Participants were asked not to undertake planned exercise outwith the lab sessions and maintain their normal lifestyle for the duration of the study. Participants completed a food diary and refrained from alcohol ingestion for 48 h prior to the first OGTT and replicated this diet before all subsequent trials. There were no differences in energy or macronutrient intake between trials on these days. Energy intake on the day prior to the OGTT (i.e. on the exercise days in the SIT and ES trials) was 2291±792 kcal in CON, 2177±842 kcal in SIT, and 2253±742 kcal in ES.

2.3. Anthropometric Assessment

Height, body mass, and skinfold thickness at four sites (biceps, triceps, subscapular and suprailiac) were measured in accordance with the International Standards for Anthropometric Assessment [22]. Percentage fat was calculated by estimating body density from skinfold measures [23] and then by applying the Siri equation [24]. Fat free mass was then determined and used to calculate the appropriate resistance for the SIT sessions.

2.4. Metabolic Testing

Participants arrived at the lab after a 12 h overnight fast. They lay in a supine position for 10 min prior to 25 min of continuous pulmonary gas exchange measurements using a ventilated hood (Oxycon Pro, Jaeger, Germany) to assess resting metabolic rate and rates of fat and carbohydrate oxidation [25]. An OGTT was then performed. A cannula