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Energy expenditure and heart rate response to breaking up sedentary time with three different physical activity interventions

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Abstract *Background and aims:* Prolonged sedentary behaviour is associated with increased cardiovascular disease risk and decreased energy expenditure (EE). Workplace interventions breaking up sedentary time have increased EE but the cardiovascular responses are unknown. The practicalities of these interventions, such as required costs and workplace adaptations, are questioned. Calisthenics exercises overcome such limitations, but have not been assessed. The aim of this study was to assess the EE and heart rate (HR) response when breaking up sedentary time with a short bout of standing, walking or calisthenics.
Methods and results: Twenty healthy participants (15 male) completed four 30 min conditions: a) 30 min sitting, or breaking up this period with two minutes of b) standing, c) treadmill walking (4 km·h^{-1}) or d) a set of calisthenics exercises (including squats and lunges). HR and EE (indirect calorimetry) were assessed throughout. During the activity break, calisthenics caused the highest HR (90 ± 12 bpm) compared to all other conditions (Sit: 70 ± 12 bpm; Stand:72 ± 13 bpm; Walk:84 ± 10 bpm; $p < 0.001$) and EE was the highest with calisthenics (13 ± 5 kcal) compared to all conditions except walking (Sit:3 ± 1 kcal; Stand:5 ± 1 kcal; $p < 0.001$). The recovery following calisthenics had highest total EE (27 ± 7 kcal) compared to walking (23 ± 6 kcal) and standing (22 ± 6 kcal) and also the longest elevation of HR ($p < 0.001$).
Conclusion: Calisthenics led to a greater total EE and HR response compared to standing or walking interventions. Calisthenics may be a time efficient method to break up sedentary time without individuals leaving their work environment. Hence calisthenics could be utilised to disrupt workplace sedentary time and improve cardiovascular health and assist in weight management.

Introduction

Time spent sedentary is increasing both in the workplace and during everyday life [1,2]. Physical inactivity has long been recognised as detrimental for cardiovascular and metabolic health [3] however, emerging research has identified sedentary behaviour as an independent health risk factor [2,4].

Prolonged sitting is associated with decreased metabolic health [1,5], cardiovascular disease [1,5,6] and increased mortality [1,2,7]. Moreover, low energy expenditure (EE) with sitting [3] is implicated in the increased prevalence of overweight and obesity [8,9], making sedentary behaviour an expanding research area within physical activity and health [2].

In a work-based environment, standing increases EE [10]. However, prolonged standing may induce lower extremity swelling, venous pooling, lower limb fatigue and

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lower back pain [11], thus longer term energy balance improvements could be negated by health complications.

Alternatively, short bouts of physical activity can be used to interrupt sedentary time. One, two and five minute self-selected speed corridor walks elevated gross EE by 3.2 kcal·30 min^{-1}, 7.6 kcalv30 min^{-1}, 16.6 kcal·30 min^{-1} respectively compared to 30 min sitting [12]. Extrapolating these results for a day, week or month, potentially leads to important increases in EE [12]. Additionally, compared to remaining seated for five hours, light and moderate intensity walking breaks every 20 min lowered resting blood pressure, however no differences were observed in heart rate (HR) [13]. Importantly, the HR responses during and immediately after the activity bouts were not measured, which can provide important information about the intensity of activity, the recovery of the cardiovascular system and may explain changes in EE.

Free walking however cannot be undertaken in all workplaces and treadmill desks are an alternative option [10]. Compared to standard desks, obese individuals walking and working for one hour increased their EE by 119 kcal·h^{-1} [8]; while in the long term overweight and obese individuals had improved body composition [14], waist and hip circumference, low-density lipoproteins and total cholesterol [9]. Treadmill desks may not interfere with workplace activities [15] but their cost may limit practical application [16] especially for an entire workforce.

Calisthenics exercises, such as body weight squats and lunges, overcome many of the limitations associated with office walking and treadmill desks. Exercises could be easily performed in small spaces, without equipment. Furthermore, calisthenics can target other fitness components, such as muscular strength, coordination, flexibility and balance, which are specified in current adult physical activity guidelines [17,18]. The use of calisthenics to break up sedentary time has not been studied; therefore any potential changes in EE are unknown.

The purpose of this study was to determine and compare the EE and HR response to breaking up sedentary time with a short bout of standing, walking or calisthenics. This would determine if calisthenics could potentially be utilised as an intervention to break up sedentary behaviour and assist in weight management.

Methods

Study population

Twenty healthy participants (15 male) completed the study (Mean ± SD, age: 24.0 ± 6.1 years, body mass: 75.2 ± 17.5 kg, height: 172.8 ± 10.7 cm, body mass index: 25.0 ± 4.2 kg/m^2). Participants were screened prior to testing (PAR-Q) and exclusion criteria included: smoking, current medication and presence of apparent cardiovascular or metabolic disease.

Study design and procedures

A within-subjects design was followed. On a single occasion participants attended the temperature controlled (20–22 °C) laboratory. Prior to testing participants were instructed to avoid strenuous exercise for 48 h and any exercise for 12 h prior, to avoid consuming caffeine or other stimulants 24 h prior and not to consume food 4 h before testing.

Following instrumentation with a HR monitor and face mask for gas collection, participants rested in a seated position for 10 min. Subsequently, in a set order four consecutive 30 min conditions were completed, each separated with a 5 min recovery period. In condition one, participants remained seated at a desk for 30 min. The further three conditions involved breaking up this sedentary time with 2 min of either: a) standing, b) low intensity walking, or c) low intensity calisthenics exercises. For each condition the same time course was followed: participants sat for 13 min, performed the physical activity intervention for 2 min and then returned to sitting for a further 15 min. To ensure a consistent physical activity time across conditions and participants, a standardised transition time between sitting to starting each intervention and then returning to sitting afterwards was included lasting 25 and 15 s respectively. Each condition was therefore broken down into five separate periods (Fig. 1).

Condition 1: sitting and other sedentary periods

During all sedentary periods participants remained seated in a chair at a desk and were permitted to read, work on a computer or perform other desk-based activities.

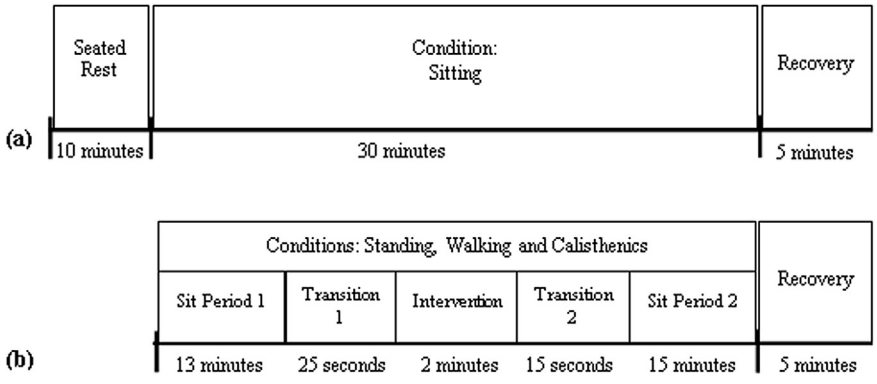

Figure 1 Experimental design for the four conditions conducted in a single 2 h laboratory session: (a) Sitting for 30 min or (b) breaking up this period with 2 min of: standing stationary, treadmill walking or calisthenics exercises.