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Research report

Effects of an acute bout of aerobic exercise on immediate and subsequent three-day food intake and energy expenditure in active and inactive pre-menopausal women taking oral contraceptives ☆

Joel Rocha [a,*], Jenny Paxman [b], Caroline Dalton [c], Edward Winter [d], David Broom [d]

[a] *Department of Physiology, School of Medicine, Faculty of Health Sciences, Trinity College Dublin, D2, Ireland*
[b] *Food and Nutrition Group, Sheffield Business School, Sheffield Hallam University, S1 1WB, UK*
[c] *Biomedical Research Centre, Faculty of Health and Wellbeing, Sheffield Hallam University, S1 1WB, UK*
[d] *Academy of Sport and Physical Activity, Faculty of Health and Wellbeing, Sheffield Hallam University, S10 2BP, UK*

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ABSTRACT

This study examined the effects of an acute bout of exercise of low-intensity on food intake and energy expenditure over four days in women taking oral contraceptives. Twenty healthy, active (n = 10) and inactive (n = 10) pre-menopausal women taking oral contraceptives completed two conditions (exercise and control), in a randomised, crossover fashion. The exercise experimental day involved cycling for one hour at an intensity equivalent to 50% of maximum oxygen uptake and two hours of rest. The control condition comprised three hours of rest. Participants arrived at the laboratory fasted overnight; breakfast was standardised and an *ad libitum* pasta lunch was consumed on each experimental day. Participants kept a food diary to measure food intake and wore an Actiheart to measure energy expenditure for the remainder of the experimental days and over the subsequent 3 days. There was a condition effect for absolute energy intake (exercise vs. control: 3363 ± 668 kJ vs. 3035 ± 752 kJ; $p = 0.033$, $d = 0.49$) and relative energy intake (exercise vs. control: 2019 ± 746 kJ vs. 2710 ± 712 kJ; $p < 0.001$, $d = -1.00$) at the *ad libitum* lunch. There were no significant differences in energy intake over the four days in active participants and there was a suppression of energy intake on the first day after the exercise experimental day compared with the same day of the control condition in inactive participants (mean difference = –1974 kJ; 95% CI –1048 to –2900 kJ, $p = 0.002$, $d = -0.89$). There was a group effect ($p = 0.001$, $d = 1.63$) for free-living energy expenditure, indicating that active participants expended more energy than inactive participants during this period. However, there were no compensatory changes in daily physical activity energy expenditure. These results support the use of low-intensity aerobic exercise as a method to induce a short-term negative energy balance in inactive women taking oral contraceptives.

Introduction

Regular exercise is prophylactic and promotes metabolic adaptations that improve physical and mental health (Bertheussen et al., 2011; Chaput et al., 2010; Tremblay & Therrien, 2006). In addition, the ability of exercise to disrupt energy balance through its effects on food intake and energy expenditure makes it important for the maintenance of adequate body mass and composition.

Exercise-induced behavioural and physiological compensatory responses in energy intake and/or non-exercise energy expenditure (King et al., 2007) might explain the high inter-variability responses of exercise interventions that are designed to reduce body mass. Additionally, these responses differ according to participants' habitual physical activity (Martins, Morgan, & Truby, 2008) and sex (Hagobian & Braun, 2010), therefore, it is important to control for these variables. Indeed, results from a recently published meta-analysis on the effect of acute exercise on subsequent (within 24 hours post-exercise) energy intake (Schubert, Desbrow, Sabapathy, & Leveritt, 2013) suggested that individuals who engage in less physical activity are more likely to experience an anorexic effect of exercise. In addition, findings from our previous study

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* Corresponding author.
E-mail address: Borgespj@tcd.ie (J. Rocha).

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(Rocha, Paxman, Dalton, Winter, & Broom, 2013) suggest that active men compensate for an acute exercise-induced energy deficit quicker than inactive men. However, it is still not known if these findings occur in women.

Most studies investigating the effects of an acute bout of exercise on hunger and food intake in active (Finlayson, Bryant, Blundell, & King, 2009; Hagobian et al., 2012; Larson-Meyer et al., 2012; Lluch, King, & Blundell, 1998, 2000) and inactive women (George & Morganstein, 2003; Maraki et al., 2005; Reger, Allison, & Kurucz, 1984; Tsofliou, Pitsiladis, Malkova, Wallace, & Lean, 2003; Unick et al., 2010) have reported no changes in hunger and/or energy intake. Despite the majority of studies reporting a consistent lack of an acute effect of exercise on energy intake, most of these studies have assessed energy intake in only one subsequent meal one to two hours post exercise (Finlayson et al., 2009; George & Morganstein, 2003; Hagobian et al., 2012; Larson-Meyer et al., 2012; Tsofliou et al., 2003; Unick et al., 2010), so any compensation that may have occurred later on the day or during subsequent days was not measured.

According to the United Nations, oral contraceptives are the most common modern contraceptive method (including both reversible and non-reversible methods) in developed countries and the third most common in developing countries (United Nations Department of Economic and Social Affairs, 2009). Oral contraceptives (OCs) have now become a feature of everyday life, with globally, nearly 200 million women taking the "pill" packet on a daily basis (Chadwick, Burkman, Tornesi, & Mahadevan, 2012). However, there is little evidence of the effects of exercise on appetite and energy intake in women taking OCs. For instance, only one study has provided information on the use of oral contraceptives by all participants (Hagobian et al., 2012), whilst several of these studies (George & Morganstein, 2003; Kissileff, Pi-Sunyer, Segal, Meltzer, & Foelsch, 1990; Maraki et al., 2005; Reger et al., 1984) examined premenopausal women without controlling variables such as the regularity of the menstrual cycles, premenstrual or unusual menstrual symptoms, menstrual phase when testing and the use of hormonal contraceptive preparations. This is despite research suggesting higher energy intakes at the luteal phase than follicular phase and that women prone to premenstrual or unusual menstrual symptoms have greater fluctuations of energy intake and appetite (Dye & Blundell, 1997). Moreover, some studies examining the effects of OCs on energy intake reported an increase (Eck et al., 1997; Naessen, Carlström, Byström, Pierre, & Lindén Hirschberg, 2007) and others no difference (Bancroft & Rennie, 1993; McVay, Copeland, & Geiselman, 2011; Tucci, Murphy, Boyland, Dye, & Halford, 2010).

Other limitations include the use of *ad libitum* buffet-style meals (George & Morganstein, 2003; Reger et al., 1984; Tsofliou et al., 2003; Unick et al., 2010), the lack of definition of participants' inactivity (Reger et al., 1984; Tsofliou et al., 2003), the estimation of energy expenditure using heart rate equations (George & Morganstein, 2003; Maraki et al., 2005) and the lack of measurement of energy expenditure (Tsofliou et al., 2003). Therefore, the present study sought to overcome some of these limitations by controlling for participants' premenstrual or unusual menstrual symptoms, menstrual phase when testing and the use of hormonal contraceptive preparations. In addition, this study increased the observation period to four days and used well-controlled and validated methods to measure *ad libitum* energy intake in the laboratory and free-living energy expenditure.

No study has examined acute effects of an acute bout of exercise on food intake and physical activity energy expenditure whilst directly comparing active and inactive women taking oral contraceptives. Findings from this study will inform whether an exercise challenge will alter these groups' physical activity and energy intake over a number of days.

Methods

Participants

With institutional ethics approval, twenty-nine healthy women were recruited. Nine participants withdrew from the study stating personal reasons (n = 4), not able to find suitable dates for the experimental days (n = 3), not liking the breakfast provided (n = 1) and feeling uncomfortable wearing the Actiheart (n = 1). Therefore, 20 healthy, active (n = 10; age 22.6 ± 3.6 years; body mass 61.4 ± 4.4 kg; body mass index 21.9 ± 1.3 kg m^{-2}) and inactive (n = 10; age 22.3 ± 3.2 years; body mass 60.1 ± 4.3 kg; body mass index 21.6 ± 2.0 kg m^{-2}) women completed the study. Participants were non-smokers, had regular menstrual cycles (21–35 days), were not pregnant or lactating, had no known history of cardiovascular or metabolic diseases, were not dieting, had a stable body mass (±2 kg) for 6 months before the study and were not taking any medication except oral contraceptives (16 participants were taking combined oral contraceptives and 4 progesterone-only pills). Severity of premenstrual symptoms was assessed through the shortened premenstrual assessment form (SPAF; Allen, McBride, & Pirie, 1991) that consists of 10 items rated on a scale from 1 (not present or no change from usual) to 6 (extreme change, perhaps noticeable even to casual acquaintances). The mean score for the SPAF for the active and inactive groups were 16.8 ± 6.8 and 17.6 ± 5.8, respectively with no participant scoring greater than 28 (scores greater than 30 are indicative of moderate premenstrual symptoms) (Allen et al., 1991). Participants' mean score for cognitive restraint based on the revised version of the Three-Factor Eating Questionnaire (Karlsson, Persson, Sjöström, & Sullivan, 2000) was 11.6 ± 3.1 for the active and 10.5 ± 3.3 for the inactive group with all participants having a cognitive restraint score lower than 18. Self-reported weekly physical activity assessed by a modified version of Godin Leisure-Time Exercise Questionnaire (GLTEQ) (Godin & Shepard, 1985) was used to allocate participants to the active (engaged in regular exercise and undertaken at least 150 minutes per week of moderate-intensity physical activity i.e., physical activity that noticeably increases breathing, sweating and heart rate and is between 12 and 14 in the 6–20 rating of perceived exertion scale) and inactive groups (did not engage in regular exercise and did not meet the minimum physical activity recommendation guidelines of 150 minutes of moderate-intensity physical activity per week) (Department of Health, 2004). Veracity of self-reported measures of physical activity was confirmed with *a posteriori* analysis of the Actiheart data. These data calculated individual Physical Activity Level (PAL) by dividing participants' total energy expenditure in a 24-hour period by their basal metabolic rate. The active group had a mean PAL of 1.79 ± 0.13 and the inactive 1.56 ± 0.15, which according to the classification of lifestyles in relation to PAL in adults (WHO, 2004) identified them as having an active to moderately active lifestyle (1.70–1.99) and a sedentary to light activity lifestyle (1.40–1.69), respectively.

Design and procedure

To minimise participant-expectancy effects, participants were blinded about the true purpose of the study (effects of an acute bout of exercise on immediate and subsequent three days energy intake and expenditure) and were informed that the investigation was assessing how food and physical activity affected mood.

Before the experimental days, participants attended the laboratory for one preliminary session consisting of two exercise tests (submaximal and maximal cycling tests), screening and habituation with all procedures. After the preliminary session, participants were allocated either to the active or inactive group and completed the study in a randomised, crossover fashion with approximately 4 weeks (time varied according to participants'