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Research report

Acute effect of walking on energy intake in overweight/obese women☆

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ABSTRACT

This study examined the acute effect of a bout of walking on hunger, energy intake, and appetite-regulating hormones [acylated ghrelin and glucagon-like peptide-1 (GLP-1)] in 19 overweight/obese women (BMI: 32.5 ± 4.3 kg/m^2). Subjects underwent two experimental testing sessions in a counter-balanced order: exercise and rest. Subjects walked at a moderate-intensity for approximately 40 min or rested for a similar duration. Subjective feelings of hunger were assessed and blood was drawn at 5-time points (pre-, post-, 30-, 60-, 120-min post-testing). Ad libitum energy intake consumed 1–2 h post-exercise/rest was assessed and similar between conditions (mean $\pm$ standard deviation; exercise: 551.5 ± 245.1 kcal [2.31 ± 1.0 MJ] vs. rest: 548.7 ± 286.9 kcal [2.29 ± 1.2 MJ]). However, when considering the energy cost of exercise, relative energy intake was significantly lower following exercise (197.8 ± 256.5 kcal [0.83 ± 1.1 MJ]) compared to rest (504.3 ± 290.1 kcal [2.11 ± 1.2 MJ]). GLP-1 was lower in the exercise vs. resting condition while acylated ghrelin and hunger were unaltered by exercise. None of these variables were associated with energy intake. In conclusion, hunger and energy intake were unaltered by a bout of walking suggesting that overweight/obese individuals do not acutely compensate for the energy cost of the exercise bout through increased caloric consumption. This allows for an energy deficit to persist post-exercise, having potentially favorable implications for weight control.

Introduction

The prevalence of obesity in the United States has risen over the past decade (Flegal, Carroll, Ogden, & Curtin, 2010). Current strategies to enhance weight loss focus on reduced dietary intake and increased physical activity, targeting both sides of the energy balance equation. However, it is unclear whether physical activity and energy intake are independent determinants of energy balance, or whether they interact with one another, having additive or synergistic effects on body weight.

Hubert and colleagues recently suggested that two methods of creating an energy deficit, exercise and calorie restriction, differentially impact subsequent feeding behaviors (Hubert, King, & Blundell, 1998). Unlike calorie restriction which results in a compensatory increase in food intake, exercise may act through a different mechanism, attenuating the need to increase feeding in response to an energy deficit created, thus favoring weight loss. Yet, the control of appetite via exercise is still somewhat controversial and it is unclear whether the influence of exercise on appetite has favorable or detrimental effects on body weight.

Studies examining the acute relationship between exercise and energy intake have reported conflicting findings (Bilski, Teleglow, Zahradnik-Bilska, Dembinski, & Warzecha, 2009), with the majority reporting no change in energy intake after exercise in a lean population (Hubert et al., 1998; Imbeault, Saint-Pierre, Almeras, & Tremblay, 1997; King & Blundell, 1995; King, Snell, Smith, & Blundell, 1996; Reger, Allison, & Kurucz, 1984; Thompson, Wolfe, & Eikelboom, 1988). However few studies have examined this relationship in an overweight/obese population and prior research demonstrates that energy intake after exercise may vary in obese and non-obese individuals (George & Morganstein, 2003; Kissileff, Pi-Sunyer, Segal, Meltzer, & Foelsch, 1990;

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Ueda et al., 2009). Whether an exercise bout influences appetite regulation in overweight/obese individuals requires further exploration and factors that may contribute to this potential relationship need to be identified.

It is hypothesized that one pathway by which exercise exerts its effects on appetite is via changes in physiological hormones involved in appetite-control. Although there are many gut peptides involved in this complex process, glucagon-like peptide 1 (GLP-1) and ghrelin both exhibit short-term effects on appetite and have previously been shown to influence feeding and satiety independently (Cummings et al., 2001; Naslund, Gutniak, Skogar, Rossner, & Hellstrom, 1998; O'Connor et al., 2006; Wren et al., 2000). Ghrelin, an orexigenic hormone, and GLP-1, an anorexigenic hormone, were chosen to be examined in the current study because previous research suggests that their concentrations are likely to be influenced by an acute exercise bout (Adam & Westerterp-Plantenga, 2004; Broom, Stensel, Bishop, Burns, & Miyashita, 2007; Marzullo et al., 2008; O'Connor et al., 1995; Ueda et al., 2009). However, very few studies have investigated whether ghrelin and GLP-1 are altered by a bout of exercise in an overweight/obese population (Marzullo et al., 2008; Ueda et al., 2009; Westerterp-Plantenga, Verwegen, Ijedema, Wijckmans, & Saris, 1997) and even fewer have concomitantly examined post-exercise changes in hormone concentrations and energy intake (King, Wasse, Broom, & Stensel, 2010; Martins, Morgan, Bloom, & Robertson, 2007; Ueda et al., 2009).

Therefore, the primary aim of this study was to examine whether a single bout of moderate-intensity walking altered short-term energy intake, subjective feelings of hunger, acylated ghrelin and GLP-1 compared to a resting control condition in overweight/obese women. A secondary aim was to examine individual energy intake responses post-exercise.

Subjects and methods

Subjects

Subjects were recruited through local flyers and online advertisements. Twenty-one pre-menopausal, overweight women participated in this study. All women were between the ages of 18 and 45 and had a BMI between 25.0 and 39.9 kg/m^2. All subjects were sedentary, defined as exercising at a moderate-intensity for less than 30 min/week over the previous six months. Subjects were excluded from participation in the study if they had a history of a chronic disease (e.g. cancer, heart disease, diabetes), uncontrolled hypertension or taking blood pressure medication, any condition that would alter one's metabolism (e.g. thyroid disease) or ability to exercise (e.g. orthopedic limitations), diagnosed psychological disorders (e.g. depression), recent weight loss of greater than 10 pounds, irregular menstrual cycles ($<$25 days or $>$35 days between cycles), or low levels of sleep ($<$6 h/night). All subjects provided written informed consent prior to participation in the study and all study procedures were approved by the Institutional Review Board at the University of Pittsburgh. Subjects were compensated $300 upon completion of all study procedures.

Study protocol

Subjects reported to the center on three separate occasions: (1) initial assessment visit, (2) exercise testing session, and (3) resting testing session. Following the initial assessment visit, the order of the testing sessions was randomly assigned. The exercise and resting testing sessions were separated by at least 2 days and testing was conducted between days 7 and 21 of the subject's menstrual cycle. Both experimental testing sessions were performed at the same time of day ($\pm$1 h) and were conducted in the morning hours. After completing both testing visits, subjects completed the Three-Factor Eating Questionnaire (Stunkard & Messick, 1985) to assess dietary restraint and disinhibition.

Assessment visit

Subjects reported to the lab between 07:30 and 09:30 having fasted overnight. Physical activity levels were assessed using the Paffenbarger Physical Activity Questionnaire (Paffenbarger, Wing, & Hyde, 1978). Height, weight, body composition (via bioelectrical impedance analysis), and resting metabolic rate (RMR) were measured using previously published procedures (Jakicic & Wing, 1998; Jakicic, Marcus, Lang, & Janney, 2008). Subjects completed an EKG monitored graded-exercise test (GXT) on a treadmill which was terminated when the subject reached 85% of age-predicted maximal heart rate. This test was performed to ensure subject safety and to allow for estimation of an exercise workload equivalent to 70–75% of age-predicted maximal heart rate (computed as 220 − age) which was needed to determine the initial grade and speed of the treadmill for the exercise testing session.

Following the completion of all testing procedures, subjects were provided with a liquid meal replacement (47% carbohydrate, 28% fat, 25% protein), equivalent to 15% of measured resting metabolic rate and instructed to consume the beverage 2 h prior to the upcoming testing visits. Subjects were asked to abstain from exercise for 2 days prior to the testing sessions and to consume only the liquid meal replacement the morning of testing.

Experimental testing sessions

Subjects reported to the lab between 7:30 and 9:30 on the morning of testing and compliance to pre-test guidelines was assessed. Body weight was measured and subjects completed questionnaires to assess mood (Watson, Clark, & Tellegen, 1988), hunger (see section below), and fatigue (McAuley & Courneya, 1994). A pre-testing blood sample was obtained via venepucture just prior to the start of the exercise or resting session. Immediately following the exercise/resting bout, the mood/hunger questionnaires were re-administered and a post-testing blood sample was obtained.

For the next 2 h, subjects rested quietly while watching a video for the first hour and reading magazines during the second hour. Additional blood draws were performed at 30, 60, and 120 min post-exercise/rest and the mood/hunger/fatigue questionnaires were administered just prior to each blood draw. After the first hour of rest, subjects were provided ad libitum access to a variety of snack foods unaware that food intake during this 1-h feeding period (1–2 h post-exercise/rest) was being monitored. The food available to the subject was as follows: bagels (plain and cinnamon raisin), cream cheese (reduced fat and regular), butter, peanut butter, granola, three types of cereal, milk (2% and fat-free), yogurt (regular and reduced fat), powdered and chocolate mini-donuts, a variety of nutrition or snack bars, mixed berries, tea, and coffee. Energy intake (EI) was determined by weighing the food before and after the 1-h feeding period. All subjects were presented with the same variety of foods which was held constant across testing days and subjects consumed these foods in isolation. Resting and exercise sessions were scheduled within 1 h of each other. Non-caloric fluid intake was monitored from immediately post-exercise until after the feeding session.

Exercise testing session

Subjects walked on a treadmill at 3.0 mph at a grade that elicited a heart rate between 70 and 75% of aged-predicted maximal heart rate. The initial grade of the treadmill was based upon an individuals' heart rate response during the GXT at the assessment visit. Heart rate was monitored continuously and