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Short communication

Gender effect on exercise-induced energy intake modification among obese adolescents☆

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ABSTRACT

This study examined gender differences in terms of energy intake and appetite feelings after an acute bout of physical exercise among obese adolescents. Seven obese girls and seven obese boys were asked to complete a sedentary and an exercise session in random order, where their food consumption and appetite sensations were assessed. Both boys and girls showed a significant reduction of energy intake on the exercise day without any modification of their appetite readings and no gender differences in food consumption and appetite responses to an acute exercise were noted.

Introduction

The impact of exercise on subsequent energy intake and appetite sensations (such as hunger, fullness, and prospective food consumption) has been explored recently and is of particular interest in terms of prevention and treatment of overweight and obesity. Recent data in obese adolescents suggest an anorexigenic effect of an acute bout of exercise, set at 70% of VO_2max, with a subsequent decrease in energy intake compared with a sedentary condition, despite unchanged appetite sensations (Thivel et al., 2010). It has been proposed that the physiological pathways regulating energy homeostasis differ between genders (Buffenstein, Poppitt, McDevitt, & Prentice, 1995; Woods, Gotoh, & Clegg, 2003). In adults, women were found to increase their energy consumption after an intensive bout of exercise (Van Strien, Frijters, Van Staveren, Defares, & Durenberg, 1986) while men did not (King, Lluch, Stubbs, & Blundell, 1997). Little data comparing boys and girls during childhood and adolescence are available. The sexual maturation occurring during adolescence may lead to gender differences in the physiological control of energy intake. Adolescence being a crucial stage for the prevention of overweight, obesity, and related metabolic diseases, it is important to determine whether boys and girls respond differently to weight loss interventions. Recent work by Bozinovski et al. (2009) asked 14 boys and 15 girls aged 9–14 years old, to complete on separate occasions rest or exercise sessions randomly, at their respective ventilator threshold. Despite a similar increase in subjective appetite in the sexes after 45 min of exercise, the authors noted that girls tended to increase their food consumption in response to their energy deficit. On average, there was 42% of the exercise-induced energy expended against −13% for boys. There was thus a strong correlation in girls between appetite and the amount of consumed food. This study involved healthy lean children, not the overweight or obese. The aim of the present study was to observe whether an acute bout of exercise differentially affects appetite and energy intake in obese adolescent boys and girls.

Subjects and methods

Fourteen pubertal obese adolescents (14.1 ± 1.8 years old; 7 girls and 7 boys; tanner stages 3 and 4) attending a specialized Children-Medical-Center (Romagnat, France) were recruited in collaboration with the Clermont-Ferrand University Pediatric Department.

Anthropometric measurements and body composition were assessed and volunteers asked to complete a graded exhaustive

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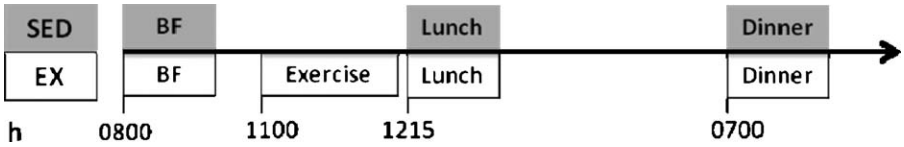

Fig. 1. Presentation of the experimental protocol: sedentary (SED) and exercise (EX) sessions.

cycling exercise to obtain their maximal oxygen uptake (VO_2max). The exercise session and a sedentary session, lasting from 0700 am to 0930 pm, were conducted randomly, one week apart.

The experimental design was approved by the relevant French authorities (CPPAU814). Information sheets describing the protocol were provided to the adolescents and their parents and signed written informed consent obtained from both.

Anthropometric measures

Weight was measured to the nearest 0.05 kg with a digital scale (Seca model 873 Omega, Germany). Height was measured with a standing stadiometer and recorded with a precision of 1 mm. Body Mass Index (kg m^{-2}) was calculated as body weight divided by height squared, and used to assess for obesity (Cole, Bellizzi, Flegal, & Dietz, 2000). Percentage of Body Fat and Fat-Free Mass were assessed by DXA (Dual-Xray absorptiometry, Hologic QDR 4500, Bedford, MA, USA).

Maximal exercise testing

VO_2max was measured during graded exhaustive cycling tests performed at least one week before experimental sessions. The initial power of 30 W was maintained during 3 min and followed by 15 W increments every 1.5 min. Children were strongly encouraged by experimenters throughout the test to perform at maximal effort.

Session design

From 0730 am to 0930 pm, adolescents were asked to avoid any engagement in physical activity, such as computer-video games or reading.

Food intake: 0830 am, a standardized breakfast was offered (2.1 MJ). Ad libitum buffet meals allowing free access to food and respecting the adolescents' taste were offered at 1215 pm and 0700 pm. At each meal food was presented in excess of expected consumption. Participants were told to eat until satisfied and that additional food was available if desired. Participants were to the extent possible not overtly informed that the real purpose of the protocol was to assess feeding responses. Food consumption was weighed and recorded by investigators (Bilnut-4 software SCDA-Nutrisoft, France) to calculate total energy intake (TEI).

Rating of appetite: At regular intervals from 0730 am until the end of day, participants were asked to rate their hunger, fullness, and desire to eat (prospective-consumption) using visual analogue scales (VAS) that have satisfactory reliability (Flint, Raben, Blundell, & Astrup, 2000).

Experimental sessions: Between 1100 am and 1145 am, adolescents were asked either to remain sedentary (SED) or to perform 30 min (3 × 10 min, 2 min-rest) of an acute exercise on a cycle-ergometer at 70% of their individual VO_2max (EX). Heart-rate monitoring (Polar.Inc-RS800CX Multi) was used to set intensity. The number of revolution per minute and the work load (in watt) were also controlled to set the intensity.

Figure 1 illustrates the experimental session (SED and EX) sequence.

Statistical analyses

Analyses were performed using Statview 5.0 (SAS-Institute Inc., NC, USA). Results are expressed as mean ± standard deviation. The Kolmogorov–Smirnov test was used to assess data distribution and unpaired *t*-tests were used to compare anthropometric values between boys and girls. ANOVA with repeated measures were used to assess energy intake modification between sessions (EX and SED). The gender difference in terms of energy intake responses during the experimental sessions (SED and EX) was assessed thanks to MANOVA. The effect of exercise interventions on appetite was examined using 2-way-ANOVA with repeated measures. Adapted post hoc tests were used when significant. Level of significance was set at 5%.

Results

The whole sample presented a Body Mass Index of 33.9 ± 7.5 kg m^{-2}. Body Fat percentage was not significantly different between boys and girls with respectively 37.4 ± 2.7% and 38.6 ± 4.2%. None of the anthropometric characteristics were significantly different between boys and girls as presented in Table 1. The 3 × 10 min of intermittent exercise at 70% VO_2max generated a mean energy expenditure of 1.25 ± 0.12 MJ.

Whole sample: The whole sample showed a significantly reduced total energy intake (whole day) during the exercise session compared with the sedentary session ($p < 0.01$). Both lunch and dinner time were also significantly reduced during the exercise session (respectively $p < 0.05$ and $p < 0.01$). None of the sensations investigated (Hunger, Appetite, and Prospective Food Consumption) were affected by exercise compared with the rest day.

Gender effect: The MANOVA showed that boys and girls did not differ in terms of energy intake between experimental sessions (sedentary vs exercise; $p = 0.60$). Hunger, satiety, and prospective food consumption (PFC) were not significantly different for both boys and girls, whatever the experimental condition (sedentary session and the exercise one). The Hunger sensation data are presented in Fig. 2.

Table 2 presents the total energy intake values and details data for lunch time and dinner time for both boys and girls during the sedentary and exercise sessions.

Discussion

To our knowledge this is the first study investigating gender effects in terms of short term energy intake and appetite feeling in

Table 1
Detailed anthropometric values between boys and girls.

	Boys ($n = 7$)	Girls ($n = 7$)
Age (years old)	13.4 ± 1.7	14.8 ± 1.7
Weight (kg)	84.05 ± 24.04	100.8 ± 31.9
Height (m)	1.61 ± 0.10	1.66 ± 0.06
BMI (kg m^2)	31.9 ± 5.4	35.95 ± 9.1
WC (cm)	109.8 ± 14.7	103.1 ± 19.9
Fat mass (%)	37.4 ± 2.7	38.6 ± 4.2

Data expressed as mean ± SD.

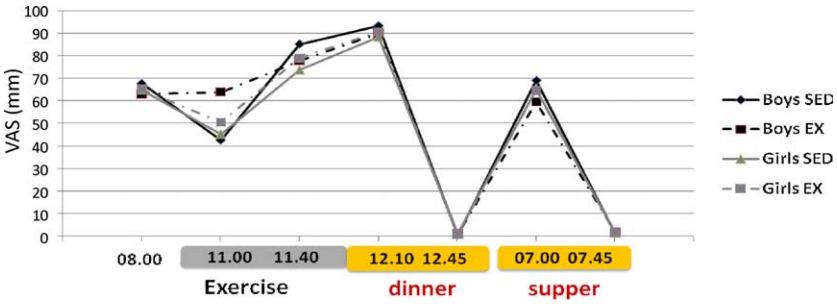

Fig. 2. Boys and girls hunger sensation during the exercise and sedentary days, assessed by visual analogue scales (VAS).

Table 2
Energy intake (MJ) detailed by gender (boys–girls) and meal (lunch–dinner).

	SED			EX		
	Lunch	Dinner	Total	Lunch	Dinner	Total
Girls	4.07 ± 0.65	3.05 ± 0.31	7.11 ± 0.87	3.69 ± 0.55	2.20 ± 0.53	5.89 ± 0.97
Boys	4.83 ± 1.34	3.02 ± 0.68	8.02 ± 1.57	4.87 ± 1.79	2.42 ± 0.64	7.30 ± 2.13

Data expressed as mean ± SD; MANOVA: not significant.

response to acute exercise in obese adolescents. As previously described by our research team, energy intake at both lunch and dinner time, is significantly reduced after an acute bout of exercise compared to a rest session in obese adolescents (Thivel et al., 2010). Normal weight children (6–11 years old) have been shown to reduce energy intake following a resistance-type exercise, whereas age-matched overweight children increased their food consumption significantly after a swimming session (Nemet, Arieli, Meckel, & Eliakim, 2010). While sex differences in the physiological regulation controlling energy balance have been proposed (Buffenstein et al., 1995; Woods et al., 2003), no work has been conducted so far directly comparing the energy intake response to acute exercise between lean or obese men and women. Adult women were found to increase their food consumption after an intensive exercise (Pomerleau, Imbeault, Parker, & Doucet, 2004; Van Strien et al., 1986) while men did not (King, Miyashita, Wasse, & Stensel, 2010; King et al., 1997; Thompson, Wolfe, & Eikelboom, 1988). Lean men and women responded differently to an acute exercise in terms of energy intake. One potential explanation may result in sex-specific secretion or sensitivity to hormones regulating food intake. Sex hormones that independently influence food intake in women (Buffenstein et al., 1995) may interact with gastro-intestinal hormones controlling food consumption (Geary, 2001), attenuating the central sensitivity to peripheral signals and then favoring food intake and weight gain. Obesity in adults leads to modifications in the relationship between exercise and subsequent energy intake regulation compared with normal weight people, but gender differences remain. Obese men have been shown to decrease their energy intake significantly after exercise (Ueda et al., 2009) while no modifications were observed in obese women (Kissileff, Pi-Sunyer, Segal, Meltzer, & Foelsch, 1990). Discrepancies may be partly explained by differences in the dieting status of the participants, i.e., whether they are in a restrained or unrestrained state. Indeed, the efficiency of physical activity in inducing a negative energy balance was found to be higher in restrained compared with unrestrained eaters (Lluch, King, & Blundell, 2000). Similar to adults, data examining gender differences in energy intake after acute exercise in children are missing. The present analysis suggests the absence of a gender effect in food consumption, Hunger, Satiety, and Prospective Food Consumption in obese adolescents of the same dieting status (unrestrained eaters). In 2009, Bozinovski and collaborators observed an increase in subjective appetite after 45 min of walking at the ventilator threshold in 9–14 years old lean boys and girls. Young boys did not change their energy intake after exercise compared with a sedentary session. However, girls showed a tendency to consume more food, which is contrary to the present data in obese subjects. Despite a non-significant gender difference in total energy intake response after acute exercise, the girls in the present work showed a reduced consumption compared to boys who did not modify their energy intake. Obesity seems then to modify the energy intake response after acute exercise compared with lean individuals, with gender differences observed in adults. In children and adolescents, however, gender differences are found in lean subjects, but obese boys and girls respond similarly to acute exercise, with girls showing a somewhat greater reduction in energy intake, which might be attributed to a lower level of disinhibition (Hill, Melby, Johnson, & Peters, 1995). It can be hypothesized that in obese young individuals, weight status dominates any differences due to gender in post exercise energy balance regulation, which may be due to the metabolic complications associated with the excess in fat mass and possibly insulin resistance.

Conclusion

Obese adolescent boys and girls decreased their food consumption after acute exercise, without modification of their appetite sensations. The post exercise appetite and energy consumption regulation of obese individuals appears unaffected by the sexual dimorphism occurring during adolescence.

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