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Is energy intake altered by a 10-week aerobic exercise intervention in obese adolescents?☆,☆☆

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HIGHLIGHTS

- Physical activity program leads to a 10% decreased energy intake in obese youth.
- Interventions have to consider potential energy expenditure compensations to physical activity.
- Physical activity not only acts on energy expenditure but also intake in obese adolescents.

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ABSTRACT

Aim: To examine energy intake adaptations to a 10-week aerobic exercise program in obese adolescents.
Methods: Twenty-six 12–17 year old obese adolescents were asked to cycle twice a week for an hour in a research laboratory. Body composition, aerobic fitness (submaximal fitness test) and energy intake (3-day food record) were assessed before and immediately after the 10-week intervention.
Results: The average time spent pedaling per session was 55.3 ± 12.1 min for a mean energy expenditure of 2196 ± 561 kJ per session. The intervention produced significant improvements in percentage of body fat (44.5 ± 10.6% vs. 43.4 ± 9.8%; $p < 0.05$) but no significant weight and fat-free mass change. Peak workload (79.5 ± 20.8 W vs. 87.3 ± 17.6 W; $p < 0.05$) and peak heart rate (174.6 ± 18.7 bpm vs. 166.2 ± 21.0 bpm; $p < 0.01$) were improved. The mean total daily energy intake (in kJ/day) showed a tendency to decrease through the intervention (7440 ± 1744 to 6740 ± 2124 kJ; $p = 0.07$) but a high inter-individual variability observed in the energy intake response to the intervention may explain the non-significant association between the energy intake response and weight loss.
Conclusion: A 10-week aerobic exercise program may result in a small decrease in energy intake and an associated decrease in percentage of body fat but no weight loss in obese adolescents. This lack of weight loss could be explained by a decrease in spontaneous energy expenditure outside the intervention sessions.

1. Introduction

The alarming progression of pediatric overweight and obesity has led to an array of diverse efforts aimed at promoting healthy eating and physical activity. The understanding and control of energy balance is certainly a key factor in the elaboration of effective recommendations and weight loss strategies. About 50 years ago it was commonly considered that energy consumption was regulated with such flexibility that increasing energy expenditure by exercise automatically led to an equivalent increased energy intake [13]. However, Mayer himself showed that physical activity was not perfectly coupled to food consumption and that a very low level of activity was related to higher caloric intake [14].

Many studies have been conducted during the last decades regarding the effects of acute exercise on the short-term control of appetite and energy intake in adults [3,12]. Although data remain conflicting so far, in lean children and adolescents, acute intensive exercise (>70% of maximal aerobic capacity — VO_2max) seems to promote a negative energy balance mainly due to a decreased daily energy intake [19,22,23]. This reduction of the subsequent energy intake is not accompanied by any alteration in appetite sensations, which is consistent with the previously observed uncoupling between appetite feelings and energy intake after exercise in obese adults [3].

Abbreviations: VO_2max, maximal oxygen consumption; BMI, body mass index; EI, energy intake; EE, energy expenditure; EB, energy balance; HR, heart rate; CHO, carbohydrates.
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Although acute exercise affects daily energy intake, exercise has to be sustained over time to favor weight loss which questioned the nutritional adaptations to long term exercise. In 2009, Caudwell and collaborators tested the effects of a 12-week physical activity program (approximate energy expenditure of 500 kcal per week) [4]. The authors concluded that physical activity alone was not enough to induce weight loss mainly because of a possible compensatory response to exercise with some patients decreasing their fruit and vegetable consumption and increasing their total energy intake [4]. This increased energy intake with exercise could be explained by the extremely powerful appetite system mechanisms that tend to protect individuals against under-eating and weight loss [2]. Previously published data in obese adolescents showed that a 6-week exercise program increased hunger and decreased fullness but the authors did not assess energy intake [9].

The nutritional (energy intake and appetite) adaptations to an exercise program are of particular interest in terms of weight loss achievement, but show an important inter-individual variability [9,10] with some patients recruiting adaptive mechanisms to oppose the negative or reduced energy balance induced by exercise [17]. To date no data are available examining the possible nutritional adaptations to an exercise program in obese youth. Accordingly, the aim of this study was to test the impact of a 10-week aerobic program on obese adolescents' energy intake and weight loss. Extrapolating from the literature, we hypothesize that adolescents will not show significant changes in energy intake or weight loss in response to the exercise intervention.

2. Methods

2.1. Population

This is a secondary analysis of data collected from participants in the GameBike trial [1] where the participants were screened through the Endocrinology Clinic at the Children's Hospital of Eastern Ontario (CHEO; Ottawa, Ontario, Canada) to determine eligibility. Of the 30 overweight/obese 12–17 year old participants that were selected (body mass index (BMI) above the 95th percentile for age and gender according to the Center for Disease Control and Prevention's growth chart data/available from http://www.cdc.gov/growthcharts), 4 dropped out prematurely due to a lack of interest and then 26 adolescents completed the study (14 females and 12 males; 14.5 ± 1.8 years old). The inclusion and exclusion criteria have been previously detailed [1]. The screening and recruitment were done between May 2007 and January 2009 and the last assessments were completed in March 2009. The protocol was approved by the Children's Hospital of Eastern Ontario (CHEO) research ethics board. All the participants and their legal guardians received information sheets and completed consent forms.

2.2. Experimental design

After a medical examination, to ensure the adolescents' ability to complete the protocol, their aerobic fitness, anthropometric characteristics, body composition and daily energy intake were assessed before and after a physical activity program. Participants were asked to visit the laboratory twice a week for 60 min for 10 weeks. During these 60-minute exercise sessions, the adolescents were asked to cycle while playing video games or listening to music. Although they were asked to stay in the lab for 60 min, they remained free to take breaks or stop cycling when they wanted. During each session, heart rate (HR) was individually monitored by a polar heart rate monitor (Polar S-510, Polar Electro Y, Kempele, Finland) for both safety and research purposes. Estimates of energy expenditure and exercise intensity were measured using the Polar heart rate monitor data, and the distance cycled was assessed by the stationary exercise bike computer system. The energy expenditure estimation was determined by a proprietary algorithm from Polar that takes into account the subject's gender, age, height and weight along with heart rate. The intensity at which the adolescents were exercising was evaluated by comparing their theoretical predicted maximal heart rate (using the 220 − age calculation) to their average heart rate during the exercise session. The 220 − age formula was chosen according to the Canadian Health Measures Survey that uses it for measuring submaximal fitness in children and youth [24].

2.2.1. Anthropometric measurements and body composition

A wall-mounted stadiometer (Seca GmBH & Co. Kg., Hamburg, Germany) was used to assess height while body weight and body composition (fat mass and fat-free mass) were assessed using a Tanita (model 300-A) bioelectrical impedance scale (Tanita Corporation of America Inc., Arlington Heights III, USA). Body mass index (BMI) was then calculated as body weight (kg) / height (m)^2. All measures were done in duplicate and the means used to resolve any discrepancies in measurements. We controlled for food consumption and hydration by measuring these at baseline and asking that subjects consume the same amount of liquids and food at the same time of day prior to post-intervention assessment. Accordingly, the adolescents were tested at the same time of the day before and after the intervention. It has been previously shown that measures from the Tanita bioelectrical impedance scale and from dual-energy X-ray absorptiometry are highly correlated in overweight and obese youth [7], demonstrating strong concurrent validity. A Seca retractable and locking ergonomic measuring tape (Seca GmBH & Co. Kg.) was also used to measure waist circumference (cm) and each measurement was taken at the midpoint between the floating rib and the iliac crest after a gentle expiration.

2.2.2. Aerobic fitness test

Pre- and post-intervention the adolescents had to complete a graded exercise protocol on a cycle ergometer to assess their submaximal aerobic fitness. They were asked to pedal at a constant speed for 3 min at a low work load and then the work load increased every 2 min by 10 W until they reached volitional fatigue. Wattage and heart rate were measured and recorded through the duration of the test.

2.2.3. Energy intake

Energy intake was assessed before and right after the 10-week intervention with the use of a 3-day food diary and the energy and macronutrient consumption was analyzed using the online dietary analysis program (www.fitday.com). This program has been shown to be a scientifically valid tool to explore energy intake in children and youth [25]. Prior to the program, the research staff have met individually with the adolescents and their parents and explained precisely how to complete the food records and how to quantify the food consumed (advices concerning the completion of the food diary were also given to the adolescents at the end of the 10 weeks).

2.2.4. Statistical analysis

Variables are presented as means ± standard deviations and the level of statistical significance set at $p < 0.05$. Statistical analyses were conducted using the SPSS software version 19.0 for Windows. Paired t-tests were used to compare baseline and post-intervention values on anthropometric measurements (height, weight, BMI, waist circumference) body composition (fat mass and fat-free mass), physical fitness (peak workload, time to exhaustion, peak heart rate) and energy intake (daily energy consumption and macronutrient intake).

3. Results

3.1. Exercise sessions' characteristics

As shown in Table 1, the participants pedaled for an average time of 55.3 ± 12.1 min during the exercise sessions with an average of 33.5 ± 15.3 min spent at moderate to vigorous intensity (60 to 79% peak heart rate) and 19.3 ± 17.4 min at vigorous intensity (80 to 100% peak heart