



Nutritional compensation to exercise- vs. diet-induced acute energy deficit in adolescents with obesity



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HIGHLIGHTS

- Obese adolescents increase intake in response to energy deficit.
- A 25% exercise-energy deficit leads to higher overall intake than a similar diet one.
- The extent for the deficit might be responsible for the compensatory intake.

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ABSTRACT

Background: To compare the energy and macronutrient intake responses to equivalent energy deficits induced by diet (food restriction) and exercise in adolescents with obesity.

Methods: Fourteen 12–15 years old obese adolescents completed three experimental conditions (08:00 am to 07:30 pm) in a randomized crossover design: i) control session (CON); ii) diet-induced 25% energy depletion (Def-EI), iii) and an exercise-induced 25% energy depletion (Def-EX). The sessions order was either CON/Def-EI/Def-EX or CON/Def-EX/Def-EI as the deficit corresponded to 25% of the energy ingested at lunch on the control day (CON) and was imposed either by exercise (Def-EX) or diet (Def-EI). *Ad libitum* EI and macronutrients preferences were assessed at dinner and appetite sensations assessed using visual analogue scales.

Results: Mean BMI was 36.6 ± 5.0 kg/m² (z-BMI: 2.40 ± 0.29). The individually calibrated 25% energy deficit represented 254 ± 92 kcal. *Ad libitum* EI was significantly higher during both Def-EX (971 ± 225 kcal) and Def-EI (949 ± 246 kcal) compared with CON (742 ± 297) ($p < 0.05$). The relative energy ingested derived from fat was significantly higher on both Def-EX ($36.6 \pm 10.9\%$) and Def-EI ($36.9 \pm 13.1\%$) compared with CON ($21.6 \pm 7.8\%$) ($p < 0.05$). The energy derived from carbohydrates was significantly lower on both Def-EX ($48.3 \pm 9.0\%$) and Def-EI ($44.4 \pm 17.3\%$) compared with CON ($61.1 \pm 10.1\%$) ($p < 0.05$). Appetite sensations were not different between conditions. The induced energy deficit was negatively correlated with the *ad libitum* EI difference between the exercise and the control session (EI Def-EX – EI CON) ($r = -0.643$ $p < 0.05$) and positively correlated with the EI difference between the dietary restriction and the control session (EI Def-EI – EI CON) ($r = 0.569$ $p < 0.05$).

Conclusion: Equicaloric exercise- or diet-induced energy deficits could lead to similar EI compensation in obese adolescents but this EI compensation might be influenced by the magnitude of the deficit.

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1. Introduction

Pediatric overweight, obesity, and their metabolic complications, are of public health concern and their constant progression highlights the urgent need for new and effective preventive strategies and weight loss programs. Preventing and treating obesity rests on the control of the energy balance, mainly by creating energy deficits through decreased energy intake and/or increased energy expenditure (through increased physical activity participation). While energy intake and expenditure have long been considered independently in the context of body weight control, there is increasing evidence to support that one could indirectly induce compensatory responses to the other [1,2]. Mayer and collaborators reported in the mid-fifties in both human [3] and animal models [4] that any increased-energy expenditure was met equally by increased energy intake, so that body weight remained stable. Since then, investigations of the compensatory mechanisms between expenditure and intake have been the subject of many studies [1,2].

In 1998, Hubert et al. compared for the first time the nutritional responses to an equivalent energy deficit induced by dietary restriction or exercise in healthy adults [5]. Interestingly, their results indicated that while an acute energy depletion induced by dietary restriction led to increased hunger feelings and energy intake at the following meal, in contrast the energy deficit induced by a bout of moderate exercise did not significantly alter perceived hunger and did not induce an increase in energy intake at the test lunch [5]. In a more recent study conducted in a similar population, these divergent short term appetite and intake responses to diet- or exercise-induced energy depletion have been attributed to changes in acylated ghrelin and PYY_{3–36} concentrations that have been found sensitive to the nature of the generated depletion (exercise or diet) [6]. Indeed, while acylated ghrelin has been found higher in the food-restriction day, PYY_{3–36} was found lower compared with the exercise condition [6]. Interestingly such compensatory responses have been found similar in healthy men and women [7].

Recent studies have questioned the impact of exercise-induced energy deficit on subsequent energy intake in children and adolescents [8–12]. While it has been clearly described that an acute bout of intensive exercise favors a transient anorexigenic effect in obese but not lean adolescents [13], this has been found uncoupled to the energy expended during exercise [14]. There is to our knowledge no study comparing the appetite and energy intake responses to an equicaloric deficit induced either by exercise or dietary restriction in youth.

The aim of the present study was thus to compare the energy intake and appetite sensations responses to equivalent energy deficits induced by diet (food restriction) and exercise in adolescents with obesity. We hypothesized that the adolescents would compensate for the induced energy-deficit by increasing their energy intake on the dietary restriction day only and not to the exercise one.

2. Materials and methods

2.1. Participants

Fourteen obese (as defined by Cole et al., 2000 [15]) adolescents aged 12–15 years old (Tanner stage 3–4 as assessed by the pediatrician after medical examination) took part in this study. Obese adolescents were recruited through pediatric consultations (Clermont-Ferrand University Hospital and Romagnat Children Medical Center, France). To be included in the study, participants had to be free of any medication that could interact with the protocol, could not present any contraindications to physical activity, and had to take part in <2 h of physical activity per week (According to the International Physical Activity Questionnaire – IPAQ) and had to be free of any food intolerance and/or aversion. All adolescents and their legal guardian received information sheets and signed consent forms as requested by the Helsinki declaration and the ethical authorities (CPP Sud Est VI).

2.2. Overview of the study protocol

First, a pediatrician performed medical inclusion visit to confirm the eligibility of participants. The adolescents had to fill in a food preference questionnaire during this first visit. They were then required to perform a maximal aerobic test and body composition was also assessed by dual-energy X-ray absorptiometry (DXA) at this time (when included in the study). The adolescents then visited the laboratory on 3 separate occasions (at least 7 days apart): 1) a control session (CON); 2) an exercise-induced energy deficit session (Def-EX); 3) a diet-induced energy deficit (Def-EI). The sessions were realized following a crossover design with the sequence of testing being either CON/Def-EI/Def-EX or CON/Def-EX/Def-EI (Fig. 1). Indeed, to calibrate the energy deficit, the CON session had to be realized first. A 25% energy deficit was imposed either by exercise (Def-EX) or diet (Def-EI) based on the energy ingested at lunch time on the control day (CON) (as previously described [6]). *Ad libitum* energy intake and appetite sensations were assessed using visual analogue scales at regular intervals through the days for the 3 experimental conditions (the main objective of this study, measuring their energy intake, was not detailed to the adolescents to avoid any influence). The adolescents were asked to avoid any moderate-to-vigorous physical exercise and to consume the same types of meals on the 24 h before each experimental session (their activity and intake were reported to a member of the investigation team on the first experimental day and this investigator gave advices to make the adolescents follow these instructions on the day prior to the two other sessions).

2.3. Description of the experimental sessions

2.3.1. Control session (CON)

After ingestion a standardized breakfast (08:30), the adolescents rested for 3 h30 hours. On the control day, both lunch and dinner (12:00 and 06:30 pm) were offered *ad libitum* to the adolescents. During the day, the adolescents were asked to remain quiet, not engaging in any moderate to intense physical activities (they were able to read, watch television, do their homework, etc., using the facilities proposed in our laboratory that is adapted to pediatric experiments).

2.3.2. Exercise-induced energy deficit session (Def-EX)

At 08:30 am the adolescents received a calibrated breakfast. Between 10:30 am and 11:45 am, the adolescents were asked to cycle on an ergocycle at 65% of their individual $\text{VO}_{2\text{max}}$. The duration of the exercise was individually calibrated to generate an energy expenditure that corresponded to 25% of the energy ingested at lunch time on CON (25% energy deficit). The intensity was controlled using heart rate records and the workload setting on the cycle ergometer, based on the results from the maximal aerobic capacity testing. At lunch time, the adolescents received a buffet identical to what they consumed for lunch on CON. They were then asked to remain quiet for the rest of the day, until 06:30 pm when they were presented with an *ad libitum* dinner meal.

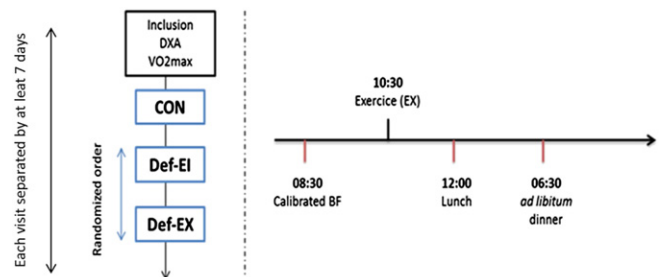


Fig. 1. Study design (CON: condition control; DEF-EX: condition exercise; DEF-EI: dietary restriction condition; BF: breakfast; EX: exercise).

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