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Original article

Impact of training and hypocaloric diet on fat oxidation and body composition in obese adolescents

Effet de l'entraînement et du régime hypocalorique sur l'oxydation des lipides et la composition corporelle chez des adolescents obèses

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Abstract

Objective. – We undertook to evaluate the effects of training and hypocaloric diet on fat oxidation and weight loss in obese adolescents within a two-month program.

Methods. – The longitudinal intervention of a two-month program was performed in 54 adolescents, whose body mass index was 30.3 ± 4.0 kg/m^2. They were divided into three groups: hypocaloric diet program (D), individualized training program at the level of maximal lipid oxidation $Lipox_{max}$ (T) and hypocaloric diet combined with training program (D + T). The body composition, the substrate "crossover" point and the $Lipox_{max}$ point were determined before and after each protocol.

Results. – The decreases in body weight and fat mass were more significant in the D + T group ($p < 0.01$) than in the D ($p < 0.05$) or T ($p = 0.07$) groups. In the D + T group, the crossover point was observed at a higher intensity at the end of the program ($+19.7\% \pm 2.4$ of W_{max}; $p < 0.001$), and the fat oxidation at $Lipox_{max}$ has increased by 83.2 ± 15.3 mg/min ($p < 0.01$). A significant correlation between $Lipox_{max}$ and weight was also observed after the program in D + T subject.

Résumé

Objectifs. – Évaluer l'effet d'un programme d'entraînement et de régime hypocalorique de deux mois sur l'oxydation des lipides et la perte de poids chez des adolescents obèses.

Méthodes. – L'intervention longitudinale de deux mois est effectuée chez 54 adolescents, dont l'indice de masse corporelle est de $30{,}3 \pm 4{,}0$ kg/m^2. Ils ont été répartis en trois groupes : régime hypocalorique (D), programme d'entraînement individualisé au point d'oxydation maximal des lipides ($Lipox_{max}$) (T) et l'association des deux (D + T). La composition corporelle, le point de croisement *crossover* et le point qui correspond au $Lipox_{max}$ sont déterminés avant et après le programme.

Résultats. – La diminution du poids et de la masse grasse est plus significative chez le groupe D + T ($p < 0{,}01$) par rapport aux groupes D ($p < 0{,}05$) et T ($p = 0{,}07$). Dans le groupe D + T, le point de *crossover* est observé à des intensités supérieures à la fin du programme ($+19{,}7\% \pm 2{,}4$ du W_{max} ; $p < 0{,}001$) et l'oxydation des lipides au point de $Lipox_{max}$ augmente de $83{,}2 \pm 15{,}3$ mg/min ($p < 0{,}01$). On a également observé une corrélation significative entre $Lipox_{max}$ et la masse corporelle après le programme chez les sujets du groupe D + T.

Keywords: Obese adolescents; Indirect calorimetry; Fat oxidation; Training; Hypocaloric diet

Mots clés : Adolescents obèses ; Calorimétrie indirecte ; Oxydation des lipides ; Entraînement ; Régime hypocalorique

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1. Introduction

The prevalence of childhood and adolescence obesity is rising alarmingly in both industrialized and developing countries [23,29]. This disease involves several health factors, originating from biological, behavioral, and environmental sources. Presumably, genetic propriety [30], progressive reduction in daily physical activities [12] and changes in nutrition habits favoring consumption of energy-dense foods [13] have been described as major factors involved in the rise of obesity in children and adolescents.

Obesity was associated to the development of excessive fat storage in adipose tissue. This major endocrine organ produces a variety of factors that regulate the metabolic energy and the sensitivity of insulin [18] as well as leptin which is an adipokin that controls food intake. Moreover, childhood and adolescence are key periods in human lives during which the prevention of obesity should be carried out because, the adipose tissue growth is phasic, in that replicative bursts occur during early childhood, at puberty and in adolescence [27].

In addition, an increase in the mass of adipose tissue is associated with insulin resistance, hyperglycemia, hypertension and other components of the metabolic syndrome such as type 2 diabetes [31]. Skeletal muscle is largely involved in the development of obesity [25]. More precisely, muscular abnormalities could alter the balance of substrate utilization, thus facilitating fat accumulation in adipose tissue. In contrast, regular exercise training, generally recommended in obese people, induces muscular metabolic changes, which can reverse these defects [11].

Diet restriction is the most common form of treatment for the obese subjects.

However, hypocaloric diet alone leads to a decrease in fat mass with a parallel decrease in fat-free mass. The decrease in muscle density can be prevented by adding exercise training to the diet [2] as suggested by Maffeis and Castellani [21] who have recently underlined the importance of physical activities in the control of body weight in children and adolescents.

Although several surveys have shown that exercise has increased the oxidation of fat in healthy [14] and obese adults [32], data in children and/or adolescents is lacking [5]. It has been shown that the intensity of exercise is one of the major determinants of substrate utilization. For instance, carbohydrate oxidation increases proportionally with the exercise load, whereas the rate of fat oxidation initially increases, but then decreases at high exercise intensity [7].

Brandou et al. [5], based on the crossover concept, [7] have shown that teenagers who had performed regular moderate exercise for a two-month period (two weeks in a specialized institute and six weeks at home), exhibited an increase in their ability to oxidize lipids at submaximal exercise. They suggested that low-intensity exercise training combined with diet program may prop up an increase in fat oxidation in obese adolescents [6].

We hypothesize that exercise training at the level of the $Lipox_{max}$ (power intensity at which lipid oxidation is maximum) combined with hypocaloric diet program would improve the regulation of energy balance and lipid metabolism; it would also shift the substrate balance towards a higher use of lipids with weight loss. Therefore, we undertook to evaluate the impacts of a two-month effect of three programs on substrate oxidation and body composition in obese adolescents: namely, hypocaloric diet (D), individualized training (T) and synergistic benefits of the two protocols (D + T).

2. Subjects and methods

2.1. Subject recruitment

The present study was conducted with the agreement of the Ministry of Education and the Ethics Committee of Farhat Hached Hospital, Sousse, Tunisia. Fifty-four Tunisian obese adolescent students (27 boys and 27 girls) participated in this study. None of the subjects had a history of chronic disease or endocrine disorder.

After receiving a comprehensive oral description of the protocol along with the risks and benefits of the study, parents and children signed a written consent. The subjects were divided in three groups of 18 subjects of equal gender (nine boys and nine girls): hypocaloric diet program (D), individualized training program at the maximal lipid oxidation point ($Lipox_{max}$) (T) and diet associated to training program (D + T).

2.2. Protocol

The objective of the investigation was to compare the outcome of the three programs over a two-month period, using anthropometric and metabolic parameters. All tests were conducted at the same hour (around 8:30 am) to avoid chronobiological effects. Subjects were asked to fast for 12 hours before performing the metabolic tests. These tests were performed in a room with its air conditioned at 24 °C and 76% humidity, during the months of June and July.

2.3. Anthropometric measurements

Body weight, height, waist and hips measurements were taken with a variability of 0.1 kg and 0.2 cm. The skinfolds thickness (in mm) was measured three times with a Harpenden caliper, and the mean value was determined from two sites: triceps and subscapular.

The body fat in percentage (BF%) was calculated using the equation of Slaughter et al. [28] for children with triceps and subscapular skinfolds less than 35 mm:

Boys: $BF\% = 1.21\ (\text{sum of 2 skinfolds}) - 0.008\ (\text{sum of 2 skinfolds}^2) - 1.7$

Girls: $BF\% = 1.33\ (\text{sum of 2 skinfolds}) - 0.013\ (\text{sum of 2 skinfolds}^2) - 2.5$

And for children with triceps and subscapular skinfolds greater than 35 mm: