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Original article

Effects of two-month physical-endurance and diet-restriction programmes on lipid profiles and insulin resistance in obese adolescent boys

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Abstract

Aim. – The aim of this study was to assess the impact of a two-month programme of physical endurance and dietary restriction, alone and combined, on plasma lipids and insulin resistance in obese adolescents.

Methods. – A total of 24 obese adolescent boys participated in programmes of either dietary restriction (R), physical endurance at the point of maximum lipid oxidation ($LIPOX_{max}$) (E) or diet combined with training (R + E). Anthropometric characteristics, metabolic measures and biochemical analyses were performed in all subjects before and after the interventions. An estimated insulin resistance was calculated using the homoeostasis model assessment (HOMA-IR) index.

Results. – At the end of the two-month programmes, adolescents in the R + E group showed greater reductions in body mass index ($-3.9 \pm 0.7\,kg/m^2$) and waist circumference (-12.3 ± 4.8 cm) ($P < 0.001$) than either the R or E group. A significant decrease ($P < 0.01$) in HOMA-IR index (-2.13 ± 0.11), plasma triglycerides, LDL and total cholesterol was also seen in the R + E group. Moreover, at the end of the programme, the ratio of HDL cholesterol to triglycerides was significantly increased from baseline in the R + E group (0.93 ± 0.09 vs. 0.68 ± 0.11; $P < 0.01$).

Conclusion. – Compared with either moderate physical endurance or dietary restriction, a combination of both resulted in a significant decrease in cardiovascular risk factors and HOMA-IR index in obese adolescent boys.

Résumé

Effet sur le profil lipidique et la résistance à l'insuline d'un programme comportant un entraînement en endurance, combiné ou non à un régime alimentaire, pendant deux mois chez des adolescents obèses.

Objet. – Évaluer les effets d'un régime alimentaire et d'un programme d'entraînement en endurance de deux mois sur la résistance à l'insuline et les lipides plasmatiques, indépendamment et combinés chez des adolescents obèses.

Méthodes. – Vingt-quatre garçons adolescents obèses ont participé au programme comparant les effets d'un régime alimentaire (R), d'un entraînement en endurance au point d'oxydation maximal des lipides ($LIPOX_{max}$) (E) et d'un régime associé à l'entraînement (R + E). Les caractéristiques anthropométriques, les mesures métaboliques et les analyses biochimiques ont été enregistrées chez tous les sujets avant et après les programmes. L'estimation de la résistance à l'insuline a été calculée par l'index HOMA-R.

Résultats. – À l'issue de ce programme, R + E a montré une diminution plus importante de l'indice de masse corporelle ($-3{,}9 \pm 0{,}7\,kg/m^2$) et du tour de taille ($-12{,}3 \pm 4{,}8$ cm) ($P < 0{,}001$) que R et E. Une diminution significative ($P < 0{,}01$) du HOMA-R ($-2{,}13 \pm 0{,}11$), des triglycérides, du LDL cholestérol et du cholestérol total a été observée chez R + E. Par ailleurs, le rapport du HDL cholestérol)/triglycérides était significativement augmenté chez R + E ($0{,}93 \pm 0{,}09$ *vs* $0{,}68 \pm 0{,}11$; $P < 0{,}01$).

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Conclusion. – Comparée au régime alimentaire seul ou à l'entraînement en endurance seul, la combinaison des deux programmes induit une réduction plus importante du niveau des facteurs de risque cardiovasculaire et de l'index HOMA-R.

Keywords: Obese adolescents; Lipid; Insulin resistance; Physical exercise; Training programme; Low-calorie diet

Mots clés : Adolescents obèses ; Lipides ; Résistance à l'insuline ; Exercice physique ; Programme d'entraînement ; Régime hypocalorique

Abbreviations

R	Diet restriction
E	Exercise training
R + E	Diet restriction combined with exercise training
$LIPOX_{max}$	point Maximal lipid oxidation point
$LIPOX_{max}$ (mg/min)	Maximal rate of lipid oxidation
COP	Crossover point
W_{max}	Maximum aerobic power
$V_{O_2\,max}$	Maximum oxygen uptake rate
HR	Heart rate
WC	Waist circumference
BF%	Body fat in percentage
FM	Fat mass
FFM	Fat free mass
PS	Pubertal status
V_{CO_2}	Dioxide of carbon rejected rate

1. Introduction

There is a global epidemic of obesity in children and adolescents in most of the developed countries today. This epidemic has been accompanied by a marked increase in the frequency of cardiovascular risk factors such as high blood pressure, dyslipidaemia and insulin resistance [1], the main component of the metabolic syndrome seen in a large number of overweight adolescents [2].

Waist circumference has been considered an acceptable surrogate marker of abdominal fat mass in adolescents [3], an increase in which is also associated with increased levels of cardiovascular risk factors [4]. An unbalanced diet and a lack of physical activity have been suggested to promote the development of excess fat storage in adipose tissue, which is an endocrine organ producing a variety of factors that can regulate energy metabolism and insulin sensitivity [5].

Skeletal muscle is the most important regulator of fat oxidation and can have a positive impact on fat-mass balance. Defects in muscle lipid metabolism have been observed in obese individuals both at rest and during exercise [6]. It is well accepted that prolonged aerobic exercise has beneficial effects on tissue sensitivity to insulin [7] and on the transport of blood lipids [8].

Weight loss has been shown to favourably affect several indicators of cardiovascular risk such as plasma lipids [9]. However, high-density lipoprotein cholesterol (HDL-C) levels are generally not improved [10]. As a low HDL-C is associated with increased cardiovascular risk [11], this may minimize the overall impact of diet on the risk of cardiovascular disease. On the other hand, exercise is associated with an increase in HDL-C [12]. For this reason, a combination of diet and exercise may be the optimal approach to controlling dyslipidaemia.

Brandou et al. [13] developed a model of maximum fat oxidation ($LIPOX_{max}$) based on the 'crossover concept' [14]. We used these two parameters to prescribe individualized exercise training for each of our study subjects.

The present study investigated the effects of diet and endurance training—alone or combined—on weight loss, insulin resistance and blood-lipid parameters in obese adolescent boys over a two-month period. We hypothesized that the combined diet and exercise regime would bring about improvements in insulin resistance and serum lipid profile via its effects on lipid oxidation during exercise.

2. Materials and methods

2.1. Subjects

We selected 24 obese adolescent boys, aged 12–14 years, whose body mass index (BMI) was greater than 97th percentile, as defined by French population curves [15]. None of the subjects were using drugs or other therapy for obesity, and none had prior histories of disease or injury that would prevent daily exercise. Consent to participate in the rehabilitation programme was obtained from each boy and his parents, and the project was approved by the Research Ethics Committee of the Faculty of Medicine, University of Sousse, in Tunisia.

The subjects were randomly assigned to one of three programme groups:

- diet (R);
- physical training at $LIPOX_{max}$ (E);
- and diet plus training (R + E).

2.2. Anthropometry

Height, weight, and hip and waist circumferences were recorded. BMI was calculated as weight in kilograms divided by height in meters squared (kg/m^2).

In all subjects, two skin-fold thicknesses (triceps and subscapular) were measured in triplicate by the same trained observer. Measurements were made on the right-hand side of the body using a Harpenden calliper.

Body-fat percentage (BF%) was calculated using the equations of Slaughter et al. [16] for boys with triceps and subscapular skin folds less than 35 mm as follows: $BF\% = 1.21 \times (\Sigma) - 0.008 \times (\Sigma)^2 - 1.7$, where Σ is the sum of two skin folds (triceps and subscapular) in millimetre.