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ORIGINAL ARTICLE

# Obese adult phenotype: Adaptations of small intestine to cafeteria diet and aerobic physical training after weaning

## *Processus adaptatifs de l'intestin grêle à un régime type cafétéria et entraînement physique de type aérobie*

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**KEYWORDS**
Diet;
Intestinal mucosal;
Physical training;
Adiposity

**Summary**
*Objective.* — This study aimed to identify the effects of cafeteria diet and aerobic physical training on morphological and metabolic parameters of duodenum and jejunum in rats.
*Methods.* — Rats were submitted to chow diet (SC), cafeteria diet (SCa), and cafeteria diet associated to aerobic physical training (TCa) on treadmill for 100 days. Body and adipose tissue weight, morphological aspects and enzymatic activity of duodenum and jejunum were measured.
*Results.* — Our results demonstrated a direct association between cafeteria diet consumption and an increase in the body weight and adiposity, which was reduced by aerobic physical training. Cafeteria diet consumption groups also presented higher villus height, but it was reduced in jejunum of trained group. In relation to enzymatic activity, only alkaline phosphatase presented higher activity in jejunum of cafeteria diet group.
*Conclusion.* — In conclusion, the small intestine submitted to cafeteria diet presented morphological/metabolic features that, in association with other aspects, may promote obese phenotype development. This could be partially reverted by aerobic physical training, which probably acts with more emphasis in another tissue/system to combat excessive adiposity.


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**MOTS CLÉS**
Alimentation ;
Muqueuse intestinale ;
Entraînement physique ;
Adiposité

**Résumé**
*Objectif.* — Cette étude a pour but d'identifier les effets de l'alimentation de type cafétéria et d'un entraînement physique aérobie sur les paramètres morphologiques et métaboliques du duodénum et du jéjunum de rats.
*Méthodes.* — Les rats ont été soumis à des alimentations contrôles (chow, SC), de type cafétéria (SCa) ou de type cafétéria associée à des exercices physiques aérobies (TCa) sur un tapis roulant pendant 100 jours. Nous avons mesuré le poids corporel, le poids des tissus adipeux, les aspects morphologiques et l'activité enzymatique du duodénum et le jéjunum.
*Résultats.* — Nos résultats ont montré une association entre la consommation alimentaire de type cafétéria et les augmentations du poids corporel et de l'adiposité ; l'exercice aérobie régulier corrige des troubles du poids et de la composition corporelle. Les groupes soumis à l'alimentation de type cafétéria ont également présenté une augmentation de la hauteur des villosités de l'intestin, mais moindre chez les animaux du groupe TCa. Seule l'activité de la phosphatase alcaline est supérieure dans le jéjunum du groupe non entraîné soumis à l'alimentation de type cafétéria.
*Conclusion.* — En conclusion, l'intestin grêle soumis au régime de type cafétéria a présenté des caractéristiques morphologiques et métaboliques qui, associées à d'autres aspects, peuvent favoriser le développement du phénotype obèse. Ce résultat pourrait être partiellement amélioré par de l'exercice physique régulier de type aérobie, qui a d'autres actions de prévention de l'adiposité.


## 1. Introduction

The maintenance of body weight is related to a balance between energy consumption and energy expenditure. When this balance is lost, body weight can be reduced (when energy expenditure is higher than energy consumption), or increased (when energy consumption is higher than energy expenditure) [1]. Therefore, diet and physical activity are life habits that influence energy balance and when performed incorrectly (high-energy density food and physical inactivity) can lead to excessive adiposity development [2—4].

Overweight and obesity are considered the major health problem in the word. These problems have also affected children [5] and adolescents [6], with an increasing incidence in young age groups. The prevalence of overweight and obesity in children is considered a public health problem, especially due to the risk of future morbidity. Thus, adequate food consumption associated to physical training during development increases the probability to result in a healthy phenotype in adult life. On the other hand, if we switch this two health habits for excessive high-energy food consumption and reduced physical training, an obese adult phenotype could be developed [6—9].

There are evidences that gastrointestinal tract alterations and physiological process of digestion can be significant factors in the development of body weight excess and high adiposity [10—13]. There are reports indicating that diet influences small intestine height [10], nutrients absorption effectiveness [13], enterocytes enzymatic activity [14—16], and morphological aspects like crypts depth and villus height [17]. In relation to aerobic physical training, data reporting its effects on morphologic and metabolic characteristics related to macronutrients absorptions in small intestine are scarce.

Previous data from our laboratory [18] shows the effect of cafeteria diet and aerobic physical training on small intestine of adult rats. In this study, we observed that cafeteria diet increases small intestine length, villi height, crypt depth, whole wall thickness and enzymatic activities of alkaline phosphatase, lipase and sucrose. Aerobic physical training increased the thickness of the muscular layer. These data demonstrate small intestine adaptations to diet and physical training starting and finishing in adult life.

In this way, we aimed to identify the effects of cafeteria diet consumption and aerobic physical training in rats, starting after weaning and lasting 100 days on duodenum and jejunum morphological and metabolic parameters.

## 2. Materials and methods

### 2.1. Animals

Twenty-four male wistar rats, 21-day-old, were submitted to treadmill running and subdivided in three groups (eight rats/group) at random according to diet and physical training regimes: sedentary normally fed rats (SC), sedentary rats fed with cafeteria diet (SCa), and trained rats fed with cafeteria diet (TCa). Animals were housed in groups of four animals per cage in the bioterium of the Department of Physiological Sciences of Maringá State University, in a controlled room temperature ($22 \pm 2\,^{\circ}C$) under a 12 h light/dark cycle (light 6 AM and dark 6 PM). All animals were weighed twice a week. All animal procedures were approved by Ethic Committee on Animal Experimentation of the Maringá State University (048/2006).

### 2.2. Diet

Animals from SC group received standard rodent chow (Nuvital-Nuvilab®) and water *ad libitum*. Animals from cafeteria groups (SCa and TCa) received palatable supermarket