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REVIEW ARTICLE

Review and analysis of physical exercise at hormonal and brain level, and its influence on appetite☆

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Abstract Due to the currently growing rate of obesity, it is important to maintain good control of food intake. The main purpose of the present study is to determine the influence of physical exercise on appetite, changes in hormone concentrations, and changes in certain neuronal regions. To achieve this, a literature search was conducted using different data bases. The results show how exercise produces changes in the appetite perception, in the amount of energy intake, and in different weight-control related hormones, as well as in specific neuronal responses. In conclusion, it can be shown that exercise leads to changes in appetite, hunger, and energy intake. In addition, exercise decreases the ghrelin levels and increases concentrations of leptin. Likewise, it is shown how physical exercise alters the responses of certain neuronal regions after visualising specific food elements decreasing so the appetite or the intake of them.
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PALABRAS CLAVE
Apetito;
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Revisión y análisis del ejercicio físico a nivel hormonal, cerebral y su influencia en el apetito

Resumen Debido a los problemas de obesidad que hay en la actualidad, es importante llevar un buen control de la ingesta alimentaria. El propósito del presente estudio es conocer la influencia que tiene el ejercicio físico sobre el apetito, los cambios generados en las concentraciones

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de diferentes hormonas y la alteración de determinadas regiones cerebrales. Para ello se ha realizado una revisión bibliográfica a través de diferentes bases de datos. En cuanto a los resultados, se aprecia que el ejercicio produce cambios en el apetito, en la cantidad de ingesta de energía, en diferentes hormonas relacionadas con el control del peso así como en determinadas respuestas neuronales. Como conclusión, se puede afirmar que el ejercicio disminuye el apetito, el hambre y la ingesta de energía. Además, el ejercicio disminuye los niveles de grelina y aumenta las concentraciones de leptina. Asimismo, se muestra como el ejercicio físico altera la actividad de ciertas regiones del cerebro tras la visualización de determinados alimentos, con lo que disminuyen el apetito o la ingesta.
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Introduction

Obesity is a disease which has taken the form of an epidemic and affects all populations. It is linked to the obesogenic lifestyle we are surrounded by, in which the combination of overeating and lack of physical activity results in an excessive accumulation of fat and increases morbidity and mortality rates among affected people.[1] As a consequence, a large number of research projects have tried to evaluate the physiological mechanisms involved in the control of energy expenditure and food intake, in an attempt to reduce the effect of obesity and maintain normal serum and histological levels of fat.[2,3]

The last 10 years have seen great advances in terms of understanding the neurohormonal and biochemical mechanisms that regulate appetite. The most important finding is the multifactorial nature of these mechanisms, whereby afferent brain stimuli, intracerebral integration of peripheral signals and efferent orders all work to establish a balance between appetite and satiety.[4]

One of the substances produced by adipose tissue is leptin, a hormone composed of 167 peptide amino acids. It is found mainly in white adipose tissue, but is also present in other tissues such as the stomach, placenta and mammary gland.[5] Leptin is considered to be a controller of body weight because it transmits information to the hypothalamus about the amount of energy stored in the adipose tissue and suppresses the appetite, which then affects energy expenditure.[6]

In addition to leptin, adipocytes also release a peptide known as ghrelin. Exogenous administration of ghrelin induces the release of growth hormone, stimulates food intake and increases body weight.[7] In this context, when fasting, leptin concentrations decrease, which stimulates the appetite and modulates the size of the intake and the perception of taste. By contrast, the amount of ghrelin increases before meals, when fasting or suffering from cachexia. Ghrelin exercises its role in the regulation of dietary intake through different mechanisms. These include the fact that it competes with leptin and also its interaction with the vagus nerve,[20] from where it can generate neuronal activation in the nucleus of the solitary tract and the dorsal motor nucleus which causes gastric motility and secretion and, in short, induces appetite and the consumption of food.[21] The hormone leptin is also involved in appetite regulation. Leptin causes activation of the catabolic effector systems. These catabolic systems reduce adiposity through inhibition of appetite. This then stimulates energy expenditure and disables anabolic effector systems, whose aim is to increase body adiposity (increasing appetite), and consequently favours the lipolysis process in adipose tissue.[22] Therefore, both ghrelin and leptin are associated with energy balance regulation.

The peptide YY (PYY) can also be found among intestinal hormones which act to control food intake. Obesity is also associated with a decrease in PYY concentrations in fasting and postprandial states.[8] PYY has consequently been identified as having potential as treatment for weight control.

Insulin has a vital function in the central nervous system in terms of inciting satiety, increasing energy expenditure and regulating the action of leptin.[9] Plasma insulin levels, like those of leptin, are proportional to the changes in adiposity; they increase in times of positive energy balance and decrease when the balance is negative.[9]

Taking all the above into consideration, manipulation of the intensity and type of physical exercise (understanding this term as a variety of planned, structured, repetitive body movements aimed at maintaining or improving physical fitness and health) may alter appetite. In support of that idea, a recent study reported that *ad libitum* intake of energy or food at a lunch and an evening meal was reduced after a high-intensity cycling session (75% VO_2 max), compared to a low-intensity session (40% VO_2 max), in obese adolescents.[10]

The objective of this review is therefore to determine how physical exercise affects the levels of certain hormones (ghrelin, leptin, insulin and PYY) and the perception of appetite (physiological or psychological sensation experienced by a subject which induces him/her to eat), how certain regions of the brain are affected after a period of exercise and how this varies according to the intensity or type of physical exercise, and its influence on individuals' feelings of hunger and satiety (understood as the length of time the feeling of satisfaction lasts before the hunger pangs return).

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