

## INTRODUCTION / INTRODUCTION

## Physical activity and diabetes: current considerations

Patrick Schrauwen

**Abstract:** The prevalence of diabetes is increasing rapidly. Overeating, leading to obesity and overweight, is often considered the main determinant of this increase. However, evidence is accumulating that physical inactivity may be as important a factor in the development of diabetes as being overweight. The reviews in this issue of *Applied Physiology, Nutrition, and Metabolism* discuss the current knowledge on the role of physical activity in the prevention and treatment of diabetes.

**Key words:** diabetes mellitus, physical activity, exercise, obesity.

**Résumé :** Il y a un accroissement rapide de la prévalence du diabète. On considère que la suralimentation, à la base de l'embonpoint et de l'obésité, est le principal facteur associé à cette augmentation. Néanmoins, de nombreuses études pointent vers l'inactivité physique comme facteur tout aussi important que le surpoids dans la manifestation du diabète. Les articles de ce numéro de la revue de *Physiologie appliquée, nutrition et métabolisme* analysent le rôle de l'activité physique dans la prévention et le traitement du diabète.

**Mots-clés :** diabète sucré, activité physique, exercice physique, obésité.

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In recent decades, we have been faced with a dramatic increase in the prevalence of diabetes mellitus, and the latest forecast of the World Health Organization predicts that 366 million people will be suffering from type 2 diabetes in the year 2030. The overabundance of energy-rich food products, leading to overweight and obesity, has generally been considered as the main determinant of this strong increase in diabetes prevalence. However, despite the fact that governmental strategies since the 1980s have been focused on increasing awareness of the negative consequences of high-fat, energy rich diets—and in fact epidemiological studies indicate that total energy intake has stabilized since then—the obesity epidemic has not come to a stop. More and more, this leads to the recognition that the epidemic cannot be halted solely by focusing on energy intake, and that the other side of the energy balance equation, energy expenditure, should be taken into account too. Indeed, the increasing prevalence of obesity is paralleled by a decrease in levels of physical activity. When the health problems related to overweight and obesity are considered, the decrease in physical activity may be an even more important factor.

The benefits of physical activity in the prevention and treatment of type 2 diabetes mellitus have been recognized

for a long time. A mechanistic explanation for these beneficial effects has been provided by the finding that type 2 diabetic patients have normal exercise-induced glucose uptake in skeletal muscle. Skeletal muscle is responsible for a major portion of the uptake of glucose in the postprandial state, mediated by an increase in circulating levels of insulin. Insulin binds to the insulin receptor expressed in muscle and ultimately leads to the translocation of a glucose transporter (GLUT4) to the plasma membrane, thereby facilitating glucose uptake. In the (pre-)diabetic state, the muscle is resistant to the effects of insulin, or insulin production is diminished, resulting in reduced muscular glucose uptake after a meal and therefore hyperglycemia. For a long time it was believed that the insulin pathway was necessary for glucose uptake into skeletal muscle. However, in the last 10 years, it has become evident that an alternative pathway exists in which muscle contraction (exercise) is able to stimulate glucose uptake and can thereby bypass muscle insulin resistance. In this issue of *Applied Physiology, Nutrition, and Metabolism*, Cartee and Wojtaszewski (2007) review the latest findings with regard to this pathway.

In addition to the acute effects of exercise on muscular glucose uptake, regular physical activity is also known to improve muscle insulin resistance and thereby glycemic control, and can prevent or at least postpone the development of diabetes. As reviewed by Østergård et al. (2007) in this issue, the mechanisms underlying these effects are not yet fully elucidated but may include the direct effects of exercise training on muscle morphology, mitochondrial function, and fiber type distribution. These findings illustrate the potential beneficial role that physical activity may play in

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prevention or delay of the development of diabetes mellitus. Moreover, it should be emphasized that physical training is also recommended for the prevention and treatment of cardiovascular disease in the general population, and this is not different in diabetic patients. Given the increased risk of cardiovascular complications in diabetes, physical activity may have double value in these patients, as it will challenge the risk of cardiovascular disease through not only improved glycemic control but also other, non-diabetes related risk factors that apply to the general population (Dela 2007)

Although physical activity seems beneficial in patients with diabetes, acute exercise may increase the risk of hypoglycemia. As mentioned earlier, exercise-induced glucose uptake is intact in diabetic patients. In type 2 diabetic patients and in hyperglycemic patients the rate of glucose uptake during exercise will be accelerated, resulting in a fall of blood glucose levels. As reviewed by Galbo et al. (2007), severe exercise in type 2 diabetic patients will, however, elicit an exaggerated counter-regulatory hormonal response that will prevent hypoglycemia, although glucose levels do drop. In type 1 diabetic patients, who lack endogenous insulin, the risk of hypoglycemia during exercise is more severe. In a series of studies, here reviewed by Briscoe et al. (2007), it was found that counter-regulatory responses are blunted during exercise following antecedent hypoglycemia. Therefore, type 1 diabetic patients need to take precautions, such as reducing pre-exercise insulin levels, adjusting carbohydrate intake before or during exercise, and not exercising after hypoglycemic events. With these practical implications taken into account, diabetic patients are well capable of performing physical activity and may benefit from the health-promoting effects that exercise may have.

Although obesity and lack of physical activity are the major determinants of the development of insulin resistance and diabetes, pregnancy is also an associated factor. During pregnancy, insulin sensitivity deteriorates as a result of the changing hormonal milieu and may result in gestational diabetes mellitus (GDM). The risk of GDM is higher among obese versus lean pregnant women. In the paper of Artal et al. (2007) and the review by Damm et al. (2007) in this issue of APNM, it is concluded that physical activity before and during pregnancy has no negative effects on pregnancy outcome but does have the potential to prevent GDM. Women with previous GDM are at increased risk of having diabetes later in life, further underscoring the importance of preventing GDM.

Taken together, the evidence outlined suggests that physi-

cal activity may be highly beneficial for the prevention and treatment of diabetes. Why, then, are the predictions of future diabetes prevalence so alarming? Part of the answer may lie in insufficient promotion of (the health benefits of) physical activity by government and other public organizations. Also, health insurance companies could be encouraged to include physical activity programmes in their packages, and in several countries such developments are currently taking place. Still, even if these prerequisites could be met, it is individuals themselves who need to take action. The paper by Kirk and De Feo (2007) reviews the strategies that have been used to promote and maintain behaviour change in physical activity. Clearly, more research is needed on that issue, as otherwise the large efforts to gain more scientific, biological, and medical knowledge about the beneficial health effects of physical activity for diabetic patients are a waste of time and money.

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