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Physical activity in prevention and treatment of type 2 diabetes mellitus

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Abstract

Type 2 diabetes in more than 70% of cases is caused by overweight and obesity. In many cases, a proper diet and increased physical activity are effective in the prevention and treatment of insulin resistance and pre-diabetes, which usually prevents the development of the disease. However, the recommendations for physical activity in type 2 diabetics differ from those for healthy people. The paper presents an analysis of recommendations concerning physical activity in the prevention and treatment of type 2 diabetes.

Key words: diabetes, obesity, insulin resistance, physical activity

Diabetes and obesity

Long-term positive energy balance results in the development of obesity and type 2 diabetes mellitus (DM2). Since the number of cases increases every year, these diseases became civilization diseases. Diabetes mellitus type 2 is a metabolic disorder characterized by hyperglycemia caused by insulin resistance of cells or impaired insulin secretion by the pancreas. Type 2 diabetes accounts for more than 90% of all types of diabetes. Moreover, at least 70% of all diabetes mellitus is caused by excess body fat, i.e. overweight or obesity (1). In overweight people, fat tissue releases increased amounts of non-esterified fatty acids, glycerol, hormones, proinflammatory cytokines and other factors that are involved in the development of insulin resistance (2). In the early stages of the disease, treatment is based on lifestyle modifications, which require an adequate diet and increased physical activity. The main aim of this treatment is to reduce the symptoms and prevent or delay the complications by maintaining the normal glucose level and the correct blood lipids and pulse pressure. Lifestyle changes and compliance with the recommendations in many cases effectively prevent the progression of the disease, improve the quality of life and reduce mortality among patients (3).

Physical activity in diabetes and obesity

Physical activity is an essential part of prevention and treatment of DM2. Studies have shown that regular physical activity and even a small reduction in body mass can reduce the risk of morbidity at any age (4). According to WHO guidelines, all healthy adults should perform at least 150 minutes of moderate-intensity aerobic exercise or at least 75 minutes of intensive aerobic exercise every week (5). The benefits of regular physical activity are a reduced risk of type 2 diabetes, ischemic heart disease, and stroke, hypertension, colon cancer, breast cancer, osteoporosis, and depression.

Type of physical activity

Due to metabolic disorders in type 2 diabetics, the recommendations for physical activity cannot be the same as in healthy individuals. A lot of research has been conducted in recent years to establish what is the most beneficial training for people with type 2 diabetes. Research has shown that aerobic exercises are the most effective in comparing to other types of physical activity. Aerobic exercise is a type of aerobic activity of constant and low intensity. This type of exercise includes walking, jogging, cycling, swimming, dancing, aerobics, nordic walking, roller-skating, jumping, etc. These exercises result in increased activity of the cardiopulmonary system and higher endurance capacity. During the workout, the energy requirement increases. Initially, muscles use their glycogen and triglyceride resources, the production of glucose in the liver increases, and if the activity in skeletal muscles is continued, the glucose consumption decreases and the consumption of free fatty acids increases. However, it is essential to keep training intensity low or moderate because during more intensive training, insufficient oxygen is absorbed by the muscles and they begin to produce energy through anaerobic processes, reducing the use of fatty acids (6).

There is no doubt that aerobic training is more effective than any other type of physical activity, but a combination of aerobic exercise and strength training is even more effective in people with type 2 diabetes. Such a combination results in, among other things, a more significant reduction in glycated hemoglobin (HbA1c) and improved glycemic control than just one kind of physical activity. Moreover, the effects of both types of exercises complement each other: aerobic exercises improve circulatory efficiency and during the resistance training muscle strength increases. The possibility of performing weight training is dependent on the individual's condition and physical abilities. In contrast to aerobic exercise, which is an essential part of diabetes management, weight training can be an additional type of physical activity that is beneficial but not necessary (7).

The intensity of physical activity

The most effective heart rate for aerobic exercises, depending on individual predispositions, is from 55% to 85% of the maximum heart rate (8). People who have not been exercising regularly so far are in poor physical condition, and therefore are unable to perform a prolonged intensive exercise because of muscle fatigue. Therefore, aerobic training should be of low to moderate intensity. Regular physical activity adapts the body to the endurance effort by increasing the number of mitochondria and respiratory capacity. Moreover, muscle strength, capacity improvements, and the use of fatty acids increase with a proportional decrease in the use of glucose, resulting in weight loss (9) (10).

As mentioned previously, people with type 2 diabetes are mostly overweight or obese. Obesity affects their mobility, which means that they are less likely to be active and involved in physical activities. In some cases, the only form of physical activity for these patients may be a low-intensity physical activity, such as walking. As walking is a safe, easy, and accessible form of physical activity, it can be easily included in the daily routine. Therefore, low-intensity walking is recommended in obese patients with type 2 diabetes and as a prevention for people at risk (11). The amount of benefits increases with increasing the speed and duration of this activity, however, it is essential to note that the equivalent energy expenditure increases the sensitivity of tissues to insulin and reduces adipose tissue to a comparable degree, regardless of the intensity of exercise. Therefore, the pro-health effect of walking can be as effective as more intensive exercise (12) (13) (14) (15).

Exercise duration

We also have to deal with a poor physical condition, which is a problem that affects obese people, people with diabetes and inactive healthy people. They are not able to tolerate long-term physical activity. However, research by Rosenkilde et al. (16) compared a group of obese men performing aerobic training every day for 30 minutes and 60 minutes and found that similar fat loss could be achieved regardless of the length of training. Although the energy expenditure induced by exercise was twice as high for men exercising 60 minutes a day than for men exercising 30 minutes a day, weight loss and fat loss were similar for both groups. Also, the negative energy balance was found to be almost identical in both groups. Researchers have interpreted this phenomenon as a result of compensation that occurs in

response to increased exercise. The human body's energy stores are protected from long-term negative energy balance by various compensation mechanisms, such as a more significant reduction in resting energy expenditure or a decrease in thermogenesis. As a result, the energy balance is less negative than can be predicted. It is suggested that it is the compensatory changes that reduce weight loss (16).

Researchers who have conducted trials on a significant number of obese women have reported comparable results. Women were divided into four groups, and each group had a different workout program: (1) high intensity/long duration, (2) moderate intensity/long duration, (3) moderate intensity/moderate duration, (4) moderate intensity/moderate duration. Weight loss was significant in all groups, but the differences between the groups were not significant. The duration of exercises and the intensity of workouts were found to have only a slight influence on the weight loss variation in particular groups (17).

Some other research also supports the thesis that the rate of weight reduction depends mainly on the amount of energy spent on exercise and not on the intensity or length of the workout (18) (19).

Effects of physical activity

Fat tissue reduction is an essential component of the successful management of type 2 diabetes. Studies have shown that people who exercise have a higher reduction in fatty tissue than those who only follow a diet (13) (14). The researches have also shown that physical activity can reduce the level of HbA1c in the blood to the point that the risk of diabetic complications is reduced in patients. It is also important to mention that the level of HcA1c reduces in a similar degree in case of exercising without a diet as in case of exercising combined with a diet. This proves that physical activity is a fundamental and essential element of diabetes management (20).

Furthermore, the beneficial effects of physical activity are not only the result of weight loss. There is a negative correlation between BMI and adiponectin, which means that as the BMI value decreases, the insulin sensitivity of tissues increases. However, it has been found that physical activity also significantly improves the insulin sensitivity of tissues by other mechanisms. It has been demonstrated in studies in which insulin sensitivity of tissues has increased, even if the level of adiponectin in the body has remained unchanged (21).

Aerobic exercise of moderate-intensity also reduces blood pressure in patients with hypertension. The most beneficial results are achieved by training 30-60 minutes from 50% to 80% of the maximum heart rate. On the other hand, more intense exercises can be the same or even less beneficial. Resistance training has no significant impact on blood pressure. In hypertensive patients, plasma lipoprotein-lipid profiles are also improved and insulin sensitivity of cells is enhanced to the same level as in those with normal blood pressure (22).

Hypoglycemia risk

Physical activity is recommended for people with diabetes to improve their disease-control, but their metabolic disorders may lead to the development of hypoglycemia. During physical activity, the energy requirement and systemic glucose intake are significantly

increased. The blood glucose level should be kept above 65 mg/dl for the whole time because it is necessary for the proper brain and nervous system functions. Carbohydrates are the fundamental resource that the human body uses during physical activity, so blood glucose is consumed quickly. A certain amount of glucose is stored in the form of glycogen and triglycerides in the muscles. To prevent hypoglycemia effectively, the production and secretion of glucose in the blood by the liver is increased. If exercise is prolonged, the glucose consumption in the skeletal muscles decreases and the consumption of free fatty acids increases (23).

Biological changes that occur during the physical activity are accompanied by a decrease in insulin levels and an increase in glucagon, adrenaline, cortisol, and growth hormone levels in the blood. Regulation of these hormones is generally effective in maintaining adequate blood glucose levels. The problem of hypoglycemia is more related to type 1 diabetes, and cases of hypoglycemia in people with type 2 diabetes are sporadic. The reason for this is that patients with type 1 diabetes have abnormalities in the secretion of not only insulin but also glucagon and adrenaline. Such patients should be under special control, but unlike them, people with type 2 diabetes should not be afraid of hypoglycemia because the risk of it is minimal. On the other hand, high-intensity exercise can cause a transient increase in blood glucose levels, which is caused by an excessive response of the "hypoglycemic" hormones (glucagon, adrenaline, noradrenaline, cortisol, growth hormone). However, the risk of this hyperglycemic crisis is mainly associated with very intense exercise ($\geq 80\%$ VO₂max) (6) (24) (25) (26).

Summary

Exercise as part of effective prevention and treatment of type 2 diabetes is essential and brings more significant benefits than just a diet. As people with type 2 diabetes and those at risk are mostly obese, it is required to adjust the type, intensity and duration of exercise to their capabilities. The recommended type of activity is aerobic exercise, which seems to be the healthiest and safest for these patients. Additional benefits are brought by including weight training in the training program. However, the ability to perform this type of exercise depends on the patient's state of health. The training intensity should also be adjusted to the predisposition of the person, however, for the body to produce energy in aerobic processes, it should not be greater than 85% of the maximum heart rate. The effort of adequate intensity - low or moderate - promotes fat burning and weight loss. Also, glucose control is improved, tissue insulin sensitivity is increased, and HbA1c levels in the blood is decreased. The recommended duration of exercise is about 30 minutes. Short-term, but more frequent physical activity is more beneficial than long-term training performed less often. In light of the studies mentioned above, 30-minute aerobic exercise with low or moderate-intensity seems to be the best choice for obese people. It should be repeated as often as possible, preferably every day.

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