Diabetes and physical training

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Summary

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Increased physical activity improves insulin sensitivity and glucose metabolism, independent of diabetes and obesity. Physical exercise is an important adjunct in the diabetes therapy. Similar to insulin, physical exercise increases the rate of glucose uptake into the contracting skeletal muscles, regulated by the translocation of GLUT4 glucose transporters to the plasma membrane and transverse tubules. Regular endurance training for elderly and diabetics has its peak cardio-pulmonary efficiency at approximately 50% of the maximum performance levels. This corresponds to a training session of at least 60 minutes. On a short-term basis, a 50% reduction of daytime and 30% reduction of night time insulin demand is to be expected, given a long training session (upwards of an hour). Oral anti diabetics (OAD) can be compensated through glucose after periods of physical strain, whereby the starting value of glucose levels should be monitored as well. Exercise training results in an increase in GLUT4 expression. So it has a beneficial effect on insulin sensitivity. Consistent training over time also achieves medium-term effects and reduces hepatic glucose production. However a 14-day interruption of training is enough to reverse the positive effects.

Key words: diabetes, physical training, insulin sensitivity, metabolic regulation, endurance training intensity

Introduction

Endurance training leads to improvements in metabolic regulation and plays a role in primary and secondary prevention of diseases. Type 2 diabetes correlates with advanced age, which in turn also corresponds to lower fitness levels. The process of degeneration begins approximately at age 40 and progresses at an increasingly faster rate with advancing age. Muscle loss, increase in body fat, general wear of the organism and decreased metabolism are the main signs of aging (7). The ability to train and achieve performance maxima is therefore reduced in the elderly population in comparison with younger age groups due to a significantly lower initial endurance and a general wear of the body (10).

Most of the signs of aging, particularly weight and fat increase, loss of muscle mass, glucose metabolism reduction and hormonal imbalance can be summed up as a result of physical inactivity. The general consequences of physical inactivity, especially in diabetic patients, are so pronounced, that even specific training fails to achieve significant short term improvements.

Endurance training for elderly and diabetics has its peak cardiopulmonary efficiency at approximately 50% of the maximum performance levels. This corresponds to a training session of at least 60 minutes.

Physical training and metabolic-/ hormone regulation

In the following the short-term training effects on hormones and metabolic regulation are given:

Short-term training effects on hormones (10)

- Insulin decrease 50%
- Growth hormone increase 300%
- Catecholamine increase 200%
- Glucagon increase 130%

Short-term training effects on metabolic regulation (8)

- Glucose uptake is increased up to 16hrs after physical training
- Concentration and activity of membrane located transporters are increased up to 2hrs after physical training

Short-term training effects on metabolic regulation (8)

- Glut4-translocation is increased up to 4hrs after physical training
- Muscle glycogen is markedly decreased
- Glucose-uptake is increased
- Depending on the duration of physical training: muscle triglycerides are decreased, FFA-uptake is increased
- Insulin sensitivity and glucose clearance are increased

Type 1 diabetes glucose regulation

Regular endurance training may decrease the insulin demand (2,5) even under conditions of normal insulin sensitivity. An increase in insulin sensitivity for up to 12 hours also influences the night time insulin demand. For type 1 diabetics with a regular workout regimen, this could mean a 50% reduction of daytime and 30% reduction of night time need for insulin (1). However, type 1 diabetics fail to achieve long-term effects through regular exercise. At most, the insulin demand is directly linked to the currently absolved training unit.

Blood sugar should always be controlled before training. Values over 180mg% (about 10 mmol x l^{-1}) require monitoring, whereas values over 250mg% are a contraindication for physical strain. In the latter case, the urine should be checked for ketone bodies, since insulin deficiency in combination with exercise stress may potentiate catecholamine and glucagon increases. This comes as a result of intramuscular glucose deficiency signalling the increase of sugar controlling hormones through vegetative afferences. The increased hepatic glycogenolysis, coupled with decreased muscular glucose absorption, may rapidly increase blood glucose levels and hyperosmolarity. All physical strain must be terminated with such signs of hyperglycaemia due to the increasing danger of hyperosmolarity or ketosis.

High glucose in the morning could be a result of nighttime hypoglycemia. Nightly controls and even a possible reduction basal insulin application are needed then.

Type 2 diabetes glucose regulation:

In the early stages this disease type is due to faulty insulin receptor sensitivity. Physical training, especially focusing on endurance, leads to a lasting reduction of insulin and blood sugar (3,4). Maximum results are observed after two hours of training and the effect on the insulin receptors can last up to 16 hours. The impact on blood sugar is theoretically great. Consistent training over time achieves medium-term effects and reduces hepatic glucose production. However a 14-day interruption of training is enough to reverse the positive effects (6). The impact on medication cannot be determined, given the differences in individual patient situation, but a consequent training regimen and good nutritional control allows patients to go without medication, even in advanced cases of diabetes. The main purpose of training, however, is to enhance the effects of the prescribed medications. On a short-term basis, a 50% reduction of daytime and 30% reduction of nighttime insulin demand is to be expected, given a long training session (upwards of an hour). Oral anti diabetics (OAD) can be compensated through glucose after periods of physical strain, whereby the starting value of glucose levels should be monitored as well. If a long-term training schedule is to be maintained, the OAD dose should be reduced by 20% and blood glucose levels should be controlled through exercise. Generally, consistent training has no relevant effect on body mass, without a simultaneous reduction of insulin or OAD.

The positive effects on blood glucose of low intensity training (30-40% of max performance levels) should not cause patients to oversee the better long-term effects of high intensity training slightly under the anaerobic threshold (55-60% of max performance levels). Due to the increased catecholamine output and the danger of mute myocardial ischemia training at the threshold level (65%) or above is not suited for diabetic patients. Targeted strength straining involving large muscle groups has similar long-term effects as endurance training. In general it is difficult to give precise advice on how to best prepare for single endurance training sessions. The level of fitness, baseline blood sugar levels, duration and intensity of training, as well as the type of insulin therapy play a role for the arrangement (1). Blood sugar and insulin levels drop less under physical strain in trained individuals (9). A larger prophylactic dose of glucose is necessary if baseline blood sugar is low (120-80mg%: 2-4KE/h; 160-120mg%: 1-2 KE/h). Roughly, blood sugar drops approximately 25-50mg% per hour of training when initial values are increased.

Middle- and long-term effects on glucose metabolism

- Glucose-uptake increase 33%
- Glut4 increase 100%
- HbA1c decrease 15%
- Decrease of basal glucose production 17%
- Decrease of hepatic glucose-output 25%

Conclusions for therapeutic training intensity in type 2 diabetic subjects

- All usual contraindications are valid
- Infectious diseases may induce cardiac complications and increase blood glucose oscillations. Infections are a general contraindication for physical strain
- An extensive medical diagnosis is necessary (eyes, kidney, heart, vessels)
- Stress test and lung function testing are recommended
- Blood pressure therapy may be necessary to increase the duration and intensity of training (blood pressure during training not over 180/90 in case of long term diabetes (>10 years)
- Dynamic endurance training at 50% of the individual maximum performance level is recommended
- The best training frequency is 4 times a week ≥45 min

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