POTENTIAL BARRIERS TO THE IMPLEMENTATION OF PHYSICAL ACTIVITY RECOMMENDATIONS IN PATIENTS WITH TYPE 1 DIABETES MELLITUS

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ABSTRACT

INTRODUCTION: *Type 1 diabetes mellitus (type 1 DM) results from the autoimmune destruction of insulin-producing beta cells in the pancreas in genetically predisposed individuals, leading to insulin deficiency and hyperglycemia. It usually manifests in childhood and adolescence, with its prevalence reaching epidemic proportions. It is a complex disease that affects not only the physical health of the individual but also their social integration and quality of life. For their treatment, patients with type 1 DM require exogenous insulin replacement therapy. Along with drug treatment, physical activity (PA) significantly impacts the health status of those diagnosed with type 1 DM.*

Physical activity, together with insulin treatment, is considered a tool for disease management and good control. The importance of PA for people with type 1 DM can be seen in improving glycemic control, blood pressure, cardiac activity, lipid profile, weight reduction, physical and mental well-being, and delaying complications.

AIM: *The aim of this review is to identify potential barriers to the implementation of physical activity recommendations in patients with type 1 DM.*

MATERIALS AND METHODS*: A systematic search and review of databases—Google Scholar, PubMed, Medscape, and ScienceDirect—over the past 10 years was conducted using the keywords: type 1 diabetes, barriers, physical activity, recommendations. An overview of recommended physical activity in type 1 DM and the difficulties in its implementation was compiled. Out of 493 articles reviewed, 68 met the criteria for full-text inclusion. Only overview articles on the subject were analyzed and included. Inclusion criteria were: patients diagnosed with type 1 DM for more than 1 year, on insulin therapy (either pump therapy or multiple daily injections of fast-acting and long-acting insulin), and aged ≥18 years. Exclusion criteria included pregnant patients or those with severe diabetic complications, chronic conditions that prevent movement (e.g., severe peripheral or autonomic neuropathy), and patients over 65 years of age for whom the International Physical Activity Questionnaire (IPAQ) was invalidated.*

RESULTS: *The analysis of the data shows that patients included in the study had an average age of 40 years and had been diagnosed with type 1 DM for a long duration, with continuous insulin treatment. To evaluate interventions, the International Physical Activity Questionnaire (IPAQ), an accelerometer, and continuous glucose monitoring (CGM) systems were often used. Overweight and obesity were prevalent among a large portion of the patients. Physical activity recommendations were implemented by only one-third of the patients enrolled in the studies.*

CONCLUSION: *Physical activity improves physical fitness and strength, reduces cardiovascular risk factors, and enhances well-being in patients with type 1 DM. It also significantly reduces insulin requirements and has been shown to improve glycemic control as measured by HbA1c.*

Keywords*: type 1 diabetes mellitus, physical activity, insulin therapy, glycemic control, overweight and obesity*

INTRODUCTION

Socio-significant diseases have a profound impact on the lives of millions of people around the world and play a key role in modern society due to their impact on health care, the economy, and the social fabric. They are the cause of mortality, morbidity, and disability in every country, primarily affecting the active and younger sections of society. These diseases pose a serious challenge and impose a significant burden on both individuals and society as a whole. The prevention and management of these diseases are becoming increasingly important in the fight to improve public health and people's quality of life. According to the International Diabetes Federation (IDF Diabetes Atlas, 10th Edition), diabetes mellitus (DM) is one of the fastest-spreading diseases of the 21st century. Globally, approximately 537 million adults live with DM, with almost half unaware of their condition. This number is expected to reach 643 million by 2030 and 783 million by 2045 (1).

Rapid economic development, increased living standards, changing lifestyles and aging make DM an important global medical problem (2-5).

Increased morbidity is associated with poor or absent physical activity (PA), unhealthy diet, arterial hypertension, overweight, obesity, stress. Often, risk factors have a combined impact, which necessitates the implementation of a complex multidisciplinary approach, including individual and public efforts for prevention, control and early detection of the disease.

DM and Physical Activity

DM is mainly divided into type 1 DM (type 1 DM) and type 2 DM. Type 1 DM is caused by the absolute destruction of insulin secretion, for which the treatment is exogenous insulin therapy (6). Physical activity (PA), together with mandatory insulin treatment and dietary regimen, is considered a tool for disease management and good control. Their balance and combined application positively affect the quality of life, physical and mental well-being of patients, as well as blood glucose (BG) values (7). Exercise therapy, including aerobic exercise, is widely recognized in the prevention and treatment of DM, as well as in the prevention of diabetic complications. However, for patients with type 1 DM, exercise poses a risk of hypo- and/or hyperglycemia. It is important to fully understand the effects of exercise on metabolism and to implement individualized exercise programs without sudden changes in BG values (1).

PA is connected to skeletal muscle contraction and the activation of energy metabolism at all levels of the human body. Physical exercise or sport includes all forms of movement with varying levels of intensity, included in daily life—for example, walking, swimming, cycling, pole climbing, housework, and other activities that increase an individual's physical endurance and well-being. Regular PA at the same time each day increases energy levels and the body's defenses (8). In elderly individuals, PA is associated with longevity, better self-esteem and quality of life, lower cardiovascular morbidity and mortality, and a lower risk of complications. For children, it provides fun, sports achievements, and friendship in the form of games (2).

Benefits of Physical Activity

Physical activity (PA) plays a key role in better blood glucose control and disease management (9). Regular physical exercise is an important part of a healthy lifestyle and has a positive pleiotropic effect. The benefits of PA improve health and quality of life at all ages (9):

Regular exercise helps to:

- reduce stress, increase energy, and improve general condition;
- gain strength and ease of movement;
- regulate blood pressure (BP) and lipid profile;
- help maintain healthy body weight and body mass index (BMI);
- reduce the level of blood glucose (BG) and improve the effect of insulin treatment in cases of insulin resistance;
- reduce the risk of micro- and macrovascular complications, osteoporosis, and neoplasms;
- improve sleep quality as well as physical and mental well-being.

When exercising, muscles need extra energy. This means that PA should be adjusted to BG levels and insulin doses. For BG values above 15 mmol/l and below 3.5 mmol/l, physical exercise is contraindicated. It is most appropriate for motor activity to occur 60-90 minutes after feeding at BG levels between 3.5 and 8 mmol/l. PA should increase gradually—from low to higher intensity—and it is often necessary to take an additional amount of carbohydrates in the form of food or drinks, before or after physical activity (energy drinks, juice, dextrose, sugar). It is important that insulin dosage is also tailored to the type and duration of exercise. Achieving a balance between PA, a diet consistent with carbohydrate intake, and insulin dosing helps avoid episodes of acute or later hypoglycemia. If necessary, a sports medicine doctor or other specialist can also be consulted to track progress or plan new or more intensive PA. Studies show that setting realistic and achievable goals and incorporating them into a daily routine improves self-management skills and the balance between nutrition, PA, and treatment. Exercise, as conceptual therapy, should be appropriately selected, individually tailored, and

adapted to the personal preferences, needs, and abilities of people with DM (10).

Recommendations for Physical Activity

The American Diabetes Association (ADA) and American College of Sports Medicine (ACSM) recommend combining mild to moderate forms of exercise, including aerobic and resistance exercise, to increase glycemic control and reduce the risk of DM-related complications. For most adults with DM, at least 150 minutes per week of moderate to intense physical activity (PA) is recommended, with brisk walking intensity at least 5 days a week. Shorter strength training sessions of 75 minutes per week are recommended for healthy and physically fit individuals (11). The exception is people with diabetic polyneuropathy and the presence of ulcers on the feet. An analysis of the sources found that combining weight training and endurance training reduced HbA1c by 0.51% and reduced the risk of long-term complications (myocardial infarction, death, macrovascular complications) by up to 76% (12-14). A positive effect on HbA1c levels, BMI, and waist circumference is also shown by guided learning in sports groups or clubs. Guided by a fitness trainer, physiotherapist, or sports medicine doctor, guided training shows high efficiency and must be completed at a pace that is not too fast to minimize the risk of injury, such as in a fall (11). Targeted training shows high efficiency and health benefits. Exercises should be balanced and tailored to the individual‘s personal preferences, improving endurance and muscle strength while preventing injury, such as in the event of a fall (11). ACSM‘s practical tips for avoiding health problems and overheating include increased fluid intake and a structured exercise program (12).

Climbing stairs instead of taking the elevator, daily shopping on foot, brisk or Nordic walking, getting off one stop earlier than a given transport, swimming, or cycling have a positive effect on the whole body. An individual attitude toward movement should be appropriately selected and tailored, but always provide pleasure. For the elderly, exercises for flexibility, muscle strength, and balance 2-3 times a week are recommended, such as yoga and tai chi, which have an additional effect on preventing falls and subsequent fractures (11,13). For complaints in the joints, swimming or cycling is recommended, while for problems with the spine, Nordic walking or swimming on the back is advised. In cases of peripheral neuropathy, high blood pressure, or disturbed cardiac or pulmonary rhythm, outdoor exercise in high temperatures and humid climates should be avoided to prevent health issues related to heat. Regardless of the choice of sport, people with DM should feel good and be sufficiently hydrated.

For those inactive for a long time, it is necessary to prepare an appropriate training plan and set an achievable personal end goal. Lack of PA and prolonged sitting can reduce the body‘s defenses and aggravate complications resulting from the disease (13). Lack of exercise also leads to low cardiopulmonary endurance and risk for people with chronic diseases (15). It is useful to alternate limited movements with gradual loading up to a zone of mild discomfort every 30 minutes. Lack of sleep impairs lipid profile, sleep quality, blood pressure, and musculoskeletal function (11). The ACSM and ADA recommend combining daily activities with planned PA.

A study conducted in Germany in 2014 among 1,003 citizens indicated lack of time as the most common reason for limited PA, followed by the presence of motor organ issues, and lack of desire and motivation to be active. Maintaining a healthy weight reduces the risk of being underweight or obese. Lifestyle changes increase motivation in people with diabetes, regulating body weight, blood sugar levels, lipids, and blood pressure. Maintaining healthy behaviors improves control and adverse disease outcomes.

PA Measurement Tools

Cost-effective and valid tools are used to accurately measure moderate to intense physical activity (MVPA) levels and sedentary behavior (SB) in older adults. Measurement occurs through the introduction of subjective (indirect) and objective (direct) instruments. Indirect measurement relies on individuals‘ ability to self-report levels of PA and sedentary behavior. This measurement approach is inexpensive, efficient, and simple, with minimal burden on participants and the research team (16).

An alternative to subjective measurement is the use of direct instruments such as accelerometers, pedometers, or combined monitors. Objective measures provide increased accuracy in monitoring and documenting an individual‘s PA, as they do not rely on self-reporting and measurement bias. This allows medical professionals to use the obtained results in treatment and in calculating daily insulin requirements (17,18).

The International Physical Activity Questionnaire (IPAQ) is a commonly used tool for assessing PA (19). Designed as a standardized self-report questionnaire, the IPAQ can be used by researchers and practitioners to assess physical activity and sedentary behavior in adults aged 15-69, in a variety of socioeconomic settings (19, 20). In addition, the IPAQ is useful in researching and comparing within or between different countries. The PA Self-Assessed

Questionnaire is an English-language version of the long self-administered version of the IPAQ (19).

Accelerometry is accomplished with small, light, and non-intrusive devices that measure acceleration in three planes. When examining PA, participants are required to wear the device on an elastic waist belt for seven days. This allows benchmarking to be performed in retrospect with a 7-day IPAQ (19).

Pedometers are small, smart devices that count steps taken, calories burned, time spent walking, and many other valuable readings. Pedometers for adults help monitor their physical condition and achievements, regardless of whether the patient practices normal or Nordic walking. The proposals and recommendations for PA are different. A 2011 review of studies summarizes step count recommendations for moderate and severe PA between 8,000 and 11,000 steps per day. The average daily number of steps for a week should be between 7,100 and 9,000 steps. There are different options for minimum daily PA (17).

The use of continuous glucose monitoring (CGM) systems provides an opportunity to report PA results in patients with type 1 DM, such as: reduction of oxidative stress, macrovascular complications, optimization of therapy in insulin treatment, and prevention of adverse events due to PA, such as hypoglycemic episodes during the day and night (17).

Barriers to PA implementation

The BAPAD-1 scale (21) is used to identify potential barriers to physical activity performance in type 1 DM. The scale includes 11 items with which participants assess barriers to PA:

- Loss of control over DM;
- Risk of hypoglycemia;
- Fear of fatigue;
- Fear of self-harm;
- Fear of a heart attack;
- Low fitness level;
- The fact that you have DM;
- Risk of hyperglycemia;
- • Actual physical health except DM;
- Weather conditions;
- Location of the gym.

Fear of hypoglycemia was identified as the highest barrier score in the current review (22–24). Other major barriers to PA and exercise include low levels of fitness, lack of time, resources, energy, willpower, and loss of control over DM, which are often among the first listed. PA may increase the risk of hypoglycemia due to an increase in insulin, which stimulates the absorption of glucose in the muscles and leads to a decrease in blood glucose (13, 25).

Literature sources indicate that in most individuals with type 1 DM, the reluctance to include more PA in their daily life stems from a lack of practical advice and preparation to prevent hypoglycemia, a strong feeling of discomfort, and a lack of knowledge to adjust insulin and carbohydrate doses before and after exercise (23, 24).

Hypoglycemia can occur during and immediately after the initiation of FA, as well as due to errors in insulin dosing and food intake (26). Cumulative insulin injection, type, intensity, and duration of exercise, and the time interval between activity and the last food intake affect glucose homeostasis (27, 28). During prolonged and strenuous activities, the glucose depots from the liver and muscles may be completely used up, and it may be necessary to adjust the dose according to the timing of the physical exercises. Even with mild, low-intensity aerobic exercise, a reduction in the insulin dose may be necessary to avoid late or nocturnal hypoglycemia. To reduce the frequency of hypoglycemic episodes, high-intensity training should precede aerobic endurance training. The order of training also has an effect on the occurrence of nocturnal hypoglycemia (29).

In order to avoid hypoglycemic fluctuations during and after FA, continuous CG monitoring is also necessary. Frequent monitoring can be replaced by CGM, with changes recorded in real-time (28). The advantages that these systems provide include analyzing the effect of FA on CG, controlling hypoglycemic states, and preventing them in the future, especially for people with diabetes who are physically active (30).

CONCLUSION

Exercise and PA are beneficial for all ages but are particularly important for people with diabetes and good disease control. Regular exercise is an important part of a healthy lifestyle and is associated with longevity and a reduced risk of complications.

PA improves physical fitness and strength, reduces cardiovascular risk factors, and enhances well-being in type 1 DM. It also significantly reduces insulin requirements and has been shown to improve glycemic control as measured by HbA1c.

However, PA remains a challenge for patients with type 1 DM, as they are at risk of hypoglycemia, identified as the highest barrier score. To eliminate hypoglycemic swings in FA, people with diabetes need to know how to adjust carbohydrate intake and insulin doses. The use of CGM systems in daily physical activities is particularly useful for faster detection and correction of glycemic fluctuations before, during, and after exercise.

The findings show that a greater proportion of participants fail to implement recommendations for

healthy levels of PA. The reason for this is the fear of hypoglycemia and subsequent hypoglycemic episodes. Most often, the reasons for this are errors in diet and insulin injection, which require consultation with a specialist and improvement of DM control.

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