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Review article

Effects of exercise on blood glucose levels in type 2 diabetic patients – Literature review

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ABSTRACT

Introduction: Diabetes is a major global health problem that affects almost 382 million people worldwide. Physical exercises have been considered as a 'gold standard' in treatment of type 2 diabetes. Nevertheless, there is still a low prevalence of exercise in diabetes population.

Aim: The aim of our study is to present the effects of resistance, aerobic, combined, and high-intensity exercise on blood glucose levels in patients with type 2 diabetes.

Material and methods: The attempt was made to investigate the effects of exercise on blood glucose levels in type 2 diabetic patients. Using keywords 'diabetes,' 'exercise,' 'glucose,' we performed a review of relevant articles based on a PubMed and Scopus online databases, focusing on the last five years.

Results and discussion: The combination of resistance and aerobic training seems to have a greater impact on glycemic control than both types of exercise alone. In addition, some studies have shown a positive effect of high-intensity exercise, especially high-intensity interval training, in the treatment of diabetes.

Conclusions: Both resistance, aerobic, and combined exercises have benefits in glycemic control for type 2 diabetic patients. The type of exercise chosen to the treatment of diabetes should be matched according to the individual clinical profile of the patient. Further studies are needed to assess the effects of high-intensity exercises on blood glucose levels in type 2 diabetes.

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1. INTRODUCTION

Diabetes is a major global health problem that affects almost 382 million people worldwide.[1] The pathogenesis of type 2 diabetes (T2D), which accounts for 85%–95% of all diabetes cases in the world, has been for a long time. Current research shows, that insulin resistance and β-cell dysfunction are the major factors in the pathogenesis of T2D.[2] However, the disease process is heterogeneous, including genetic and environmental determinants such as physical inactivity and poor nutrition.[3,4] The environmental determinants of insulin resistance and β-cell dysfunction are strongly associated with obesity and a sedentary lifestyle. Thus, physical exercise has been considered as a 'gold standard' in the treatment of T2D. This non-pharmacological therapeutic strategy improves glycaemic control and insulin sensitivity.[5] Moreover, physical exercises have a positive impact on body composition, blood pressure and lipid profile, which disorders can be a predictor of T2D.[6] European Association for the Study of Diabetes and American Diabetes Association pay attention to the important role of well-planned effort in the treatment of diabetes, especially of type 2.[7,8] Furthermore, individuals at high risk for developing T2D can significantly decrease the rate of diabetes onset by lifestyle intervention, such as increasing physical activity to at least 150 min/week of moderate activity and weight loss of 7% of body weight.[8]

Nevertheless, in some countries there is still a low prevalence of exercise practice in patients with T2D.[9] It might be due to the lack of knowledge about potential benefits of physical exercises and current international recommendations for diabetic patients.[10] Over the last few years, more research is using a continuous glucose monitoring system, which gives unprecedented access to control patient's blood glucose levels.[11,12] In spite of this, there is still a lack of studies demonstrating which type of exercise should be recommended for T2D. Scientific organisations (International Diabetes Federation, European Association for the Study of Diabetes, American College of Sports Medicine, American Diabetes Association, American Heart Association, Belgian Physical Therapy Association, Canadian Diabetes Association, European Society of Cardiology, Exercise and Sports Science Australia, Francophone Diabetes Society, Swedish National Institute of Public Health) recommend both aerobic activity, resistance exercise and combined aerobic/resistance training.[13] In addition, some studies have shown a positive effect of high-intensity exercise, especially high-intensity interval training, in the treatment of diabetes, including the increase of glucose uptake and improvement of mitochondrial function.[14–16]

Therefore, exercise volume and the type of training should be carefully analyzed and matched to the medical profile of the diabetic patient, which may be a major determinant of proper glucose level.

2. AIM

The aim of our study is to present the effects of resistance, aerobic, combined, and high-intensity exercise on blood glucose levels in patients with T2D.

3. MATERIAL AND METHODS

The attempt was made to investigate the effects of exercise on blood glucose levels in type 2 diabetic patients. Using keywords 'diabetes,' 'exercise,' 'glucose,' we performed a review of relevant articles based on a PubMed and Scopus online databases, focusing on last five years.

4. RESULTS AND DISCUSSION

4.1 Resistance exercise

Resistance exercise is an anaerobic type of training, which is used to increase muscular strength, power, and endurance by varying the resistance intensity range between 50%–75% of 1-repetition maximum.[17,18] Well-planned, ten-week resistance training may increase resting metabolic rate by 7% and reduce fat weight by 1.8 kg.[19] By decreasing visceral fat and improving insulin sensitivity and glucose control, resistance training can be a useful tool in the treatment of T2D. Hence, resistance exercise for T2D is recommended by national and international organisations.[20–22] According to Position Statement of the American Diabetes Association, resistance training of any intensity is recommended for diabetic patients to improve strength, balance, and ability to engage in activities of daily living throughout the life span. In addition, adults with diabetes should engage in 2–3 sessions/week of resistance exercise on nonconsecutive days (1).[23] Moreover, Ishiguro et al. (2016) Systematic Review and Meta-Analysis suggests that the resistance training could be recommended in the early stage of T2D, especially for patients with relatively poor glycaemic control.[24] However, there is no agreement on detailed duration, dosage and resistance exercise programs.[13]

The positive effect of exercise on blood glucose level and diabetes treatment has been demonstrated in many studies over the years.[25] However, in the last five years, only a few papers dealt with this issue. Russell et al. (2017) study showed that resistance training improves glycaemic control (fasting blood glucose, HbA1c, and glucose area under the curve).[26] The significant differences between the resistance exercise group and the control group in the reduction of glucose level (22.21%Δ vs. 7.99%Δ, respectively; $P < 0.05$) was found by AminiLari et al. (2017).[27] Moreover, improvements in glycaemic control and glucose homeostasisin type 2 diabetic patients were also reported by Hameed et al. (2012), Mavros et al. (2013), and Hsieh et al (2016) studies.[28–30]

4.2 Aerobic exercise

Aerobic type of training involving large muscle groups with low and middle intensity can be performed safely by diabetic patients. Aerobic exercises such as running, walking,

cycling, swimming, and rowing, are typically included in this category of training.[18,31] International diabetes societies recommended 150 minutes of aerobic exercise spread over a minimum of three days per week with moderate intensity (40%–59% of heart rate reserve, 64%–76% of the maximum heart rate) with no more than two consecutive days without exercise.[13] American Diabetes Association recommended for adults with T2D regular aerobic activities that last at least 10 minutes, with the goal of 30 min/day or more, most days of the week.[23]

Van Dijk et al. (2013) study reported the effectiveness of aerobic-endurance exercises in improving glycaemic control. A single bout of moderate-intensity exercise lowered average blood glucose concentrations by 0.9 mmol/L and reduced glycaemic variability (0.7 to 1.2; $P < 0.05$).[32] Moreover, the single 45-minutes bout of moderate-intensity exercise (6 METs) reduced the glycaemic response to breakfast, lunch, and dinner ($P < 0.05$ for all postprandial periods).[33] Nygaard et al. (2017) showed significant decrease of the glycaemic variability after aerobic postprandial exercises compared to the control day (1.22 ± 0.49 mmol/L vs. 1.58 ± 0.52 mmol/L, respectively; $P < 0.05$). They also observed decrease in the mean of the 10 highest glucose values measured after exercises in each individual (8.6 ± 1.9 mmol/L).[34] The positive effect of aerobic exercise on glycaemic control has been demonstrated also by AminiLari et al. (2017). The study protocol has consisted of 3 sessions per week for 12 weeks (25 minutes exercise in order to achieve 50%–55% of maximum heart rate). In this study, the reduction of glucose level was observed in comparison to controls (24.58%Δ vs. 7.99%Δ, respectively; $P < 0.05$).[27]

The differences between resistance and aerobic exercises were analyzed several times in the literature. Although numerous studies reported statistical significance differences in diabetic control measures between resistance and aerobic exercise training programmes, there is no evidence that they are of clinical importance.[25]

4.3 Combined aerobic and resistance exercise

Both resistance and aerobic training have a positive therapeutic effect in the treatment and control of T2D. However, the combination of both types of training seems to have a greater impact on glycaemic control than both types of exercise alone.[13,22,35]

Kang et al. (2016) study confirms the effectiveness of combined exercise in the insulin resistance improvement and blood glucose control enhancing. The 12 weeks combined aerobic and resistance training programme reduced significantly fasting blood glucose concentration (Pre: 139.5 ± 12.3 mg/dL, Post: 132.9 ± 11.6 mg/dL; $P < 0.001$).[36] The study Liu et al. (2015) evaluated the difference between combined aerobic/resistance exercises and conventional treatment during 12 weeks. The authors observed the reduction of postprandial blood glucose level after combined training in comparison to the conventional therapy group (9.00 ± 1.91 mmol/L vs. 7.30 ± 0.98 mmol/L, respectively; $P < 0.01$).[37] Moreover, Tan et al. (2012) showed significant reduction of the fasting blood glucose concentration after 6 months of combined intervention in comparison to controls (6.19 ± 1.47 mmol/L vs. 6.69 ± 1.73 mmol/L, respectively; $P < 0.05$).[38] Similar results were obtained by AminiLari et al. (2017), Yalamanchi et al. (2016), Adeniyi et al. (2013), and Jorge et al. (2011).[27,39–41]

4.4 High-intensity exercise

High-intensity interval training (HIT) is an increasingly popular form of time-efficient exercises program, consisting brief bursts of very vigorous exercise (≥90% VO_{2max}) separated by brief recovery periods.[42] Although the large group of studies has demonstrated the ability of HIT to produce large gains in both aerobic and anaerobic exercise ability in rehabilitation, only several studies described this type of effort in the management of diabetes.[43] Moreover, according to Position Statement of the American Diabetes Association, those diabetic patients, who wish to perform HIT, should be clinically stable, have been participating at least in regular moderate-intensity exercise, and should be supervised during the first stage of exercise.[23]

Lee et al. (2015) finding indicate that the 12 week high-intensity exercise program ($n = 10$; 3 trainings per week at not less than 80% heart rate reserve) resulted in more positive changes in glycemic control (fasting glucose, C-peptide, homeostasis model assessment 2 of insulin resistance; $P < 0.05$) in type 2 diabetic patients than the typical low-intensity exercise training ($n = 10$; 6 trainings per week at not more than 40% heart rate reserve).[44] Gillen et al. (2012) study reported, that HIT reduced hyperglycaemia above 10 mmol/L (HIT: 4.5 ± 4.4 mmol/L vs. CTL: 15.2 ± 12.3 mmol/L, $P = 0.04$) and postprandial hyperglycaemia (HIT: 728 ± 331 mmol/L • 9 h vs. CTL: 1142 ± 556 mmol/L • 9 h, $P = 0.01$). The study protocol consisted of 10 × 60 s cycling efforts at ~90% maximal heart rate, interspersed with 60 s rest and involved a small number of diabetic patients ($n = 7$) in a short continuous glucose monitoring system monitoring period (24 hours).[14] The similar protocol used by Little et al. (2011), which examined the effects of 2 week HIT on glucose regulation showed the reduction of average 24-hours blood glucose concentration after training (7.6 ± 1.0 mmol/L vs. 6.6 ± 0.7 mmol/L; $P < 0.05$). However, the study only reported on eight participants.[15] Thus, lack of studies and small study groups in existing research do not allow assessing the effects of high-intensity exercise on blood glucose levels and the effectiveness of this method in the management of diabetes. In addition, the high prevalence of co-morbid illness (hypertension, cardiovascular disease) in diabetes can also be a contraindication to exercise an intensity of 90% maximal heart rate.[45] Hence, perhaps this type of exercise is not included in the recommendations of diabetic associations.

5. CONCLUSIONS

1. Both resistance, aerobic, and combined exercises have benefits in glycaemic control for type 2 diabetic patients.

2. The type of exercise chosen to the treatment of diabetes should be matched according to the individual clinical profile of the patient.
3. Further studies are needed to assess the effects of high-intensity exercises on blood glucose levels in T2D.

Conflict of interest

The authors declare that they have no conflict of interest.

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The results of the present study do not constitute endorsement of the product by the authors or the journal.

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