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STUDY OF TYPES OF EXERCISE TRAINING ON SELECTED FACTORS IN TYPE 2 DIABETES

(Review study)

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Abstract

Different exercise training can have different effects on the control and treatment of diabetes, therefore, the aim of the present study was to study types of exercise training on factors related to type 2 diabetes. The research method was descriptive-library and a search was conducted in Magiran, Google scholar, Science Direct, and PubMed databases with the keywords Insulin sensitivity, diabetes, High-intensity interval training, resistance training, exercise training and HbA1c, resistance training, high-intensity interval training, aerobic training, combined exercise, type 2 diabetes and insulin sensitivity to retrieve articles published in the period from 2010 to 2025.

Aerobic exercise, especially high-intensity interval training (HIIT), can have faster effects on blood sugar control and reduction in patients, however, the positive effects of resistance training remain for a longer period of time. According to the results of the study, we conclude that the beneficial effects of resistance training can last for a longer time compared to endurance training, both aerobic and resistance training improve insulin action and are effective in blood glucose management and quality of life. Of course, it should be noted that to benefit from these benefits, exercise must be done regularly and continuously, | Therefore, it is recommended that medical and sports specialists pay attention to the importance of the type and form of exercise when presenting exercise programs to diabetic patients.

Keywords: Aerobic exercise, resistance training, combined exercise, type 2 diabetes

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1. Introduction

Diabetes is a metabolic disease whose prevalence is increasing day by day. Type 2 diabetes is an epidemic metabolic disease that, according to estimates, affects about 5 to 8 percent of adults worldwide. The International Diabetes Federation reported that the number of people with type 2 diabetes in 2010 was 285 million worldwide and predicts that this number will reach 438 million by 2030 (Sadighi et al., 2024). On the other hand, studies have shown that in 2013, there were 328 million diabetics in the world, which is expected to reach 438 million by 2030 and 592 million by 2035. It is estimated that the prevalence of diabetes in the world will reach about 21 percent by 2050. Diabetes is a metabolic disease characterized by chronic elevation of blood sugar and disturbances in carbohydrate, fat, and protein metabolism. It results from defects in insulin secretion, insulin action, or both (Dakani et al., 2021; Thomas et al., 2010). The risk of premature mortality, heart disease, kidney disease, neuropathy, and blindness in diabetics is twice that of nondiabetics. In general, type 2 diabetes accounts for 90-95% of the prevalence of this disease and is caused by the inability of muscle cells to respond to insulin (insulin resistance) and insufficient compensatory insulin secretion (Darvishi et al., 2024). Apart from diabetic patients, there is also a group of people whose blood glucose control is abnormal, although they do not meet the diagnostic criteria for diabetes, these people are called prediabetes. Prediabetes is defined as a disease in which their fasting glucose status (100 to 120 mg/dL) and glucose tolerance (2-hour glucose 140 to 199 mg/dL) are impaired and if not treated, they will soon develop type 2 diabetes (Pattarawat et al., 2025). This is while, in recent decades, physical activity along with diet and medication has been considered as the main treatments for diabetes (Mafhoom et al., 2024; Pattarawat et al., 2025). According to the American Diabetes Association and the American College of Sports Medicine, and according to pilot studies, physical activity and exercise are recommended for the prevention and treatment of diabetes (Knaga & Buresh, 2022; Koo et al., 2021). Although regular physical activity may play a role in the prevention and treatment of diabetes and its complications, most people at risk of type 2 diabetes are inactive. On the other hand, despite the importance of physical activity in improving diabetes conditions, there is much debate about prescribing an exercise program for the health of these people (Jia et al., 2024). This review article attempts to provide information about the beneficial effects of exercise in type 2 diabetics, and to provide guidelines for prescribing an exercise program for these people. However, the terms physical activity and exercise represent two different concepts. Physical activity refers to any movement produced by skeletal muscles that results in energy expenditure (in kilocalories) and includes a wide range of occupational, leisure, and daily activities. While exercise refers to planned or structured physical activity that involves repetitive bodily movements and improves or maintains one or more components of physical fitness such as (aerobic capacity, muscular strength, muscular endurance, flexibility, body composition, etc.). This is while the American College of Sports Medicine recommends that patients with type 2 diabetes should consume at least 1000 kilocalories per week through physical activity (Jansson et al., 2022). The American Diabetes Association has introduced four criteria for diagnosing diabetes, including 1) a glycosylated hemoglobin (A1c) level of 6.5% or higher. 2) a fasting glucose level of 126 mg/dL or higher. 3) a 2-hour plasma glucose level of 200 mg/dL or higher during a 75-gram oral glucose tolerance test, and 4) symptoms of hyperglycemia, including polyuria, polydipsia, and unexplained weight loss. On the other hand, prediabetes is characterized by an A1c of about 7.5 to 4.6%, a fasting glucose of 100 to 125 mg/dL, and impaired glucose tolerance, i.e., a 2-hour plasma glucose of 140 to 199 mg/dL after a glucose load (Al-Awadi et al., 2025; Dakani et al., 2021). Diabetes is broadly classified into two forms: glycaemic and non-glycaemic. Diabetes insipidus is a disorder of the hormonal system in which there is often a deficiency of antidiuretic hormone, which is naturally secreted by the posterior pituitary gland (Sun

et al., 2024). In diabetes insipidus, there is no disturbance in blood sugar and it resembles diabetes only due to an increase in urine volume. Diabetes mellitus is classified into two main forms: type 1 and type 2 (Al-Ozairi et al., 2021). In type 1 diabetes, which accounts for about 5 to 10 percent of cases, the disease is the result of a disorder in the immune system of insulin-producing cells in the pancreas. Type 2 diabetes, which accounts for about 90 to 95 percent of diabetes cases, is caused by the inability of muscle cells to respond to insulin (insulin resistance). Overall, the results of the research showed that physical activity can significantly improve glycemic control in patients with type 2 diabetes. Pan et al. systematically reviewed and meta-analyzed 37 articles that were derived from aerobic and resistance training in people with type 2 diabetes (Jia et al., 2024).

Maintaining normal blood glucose levels during rest and exercise depends on the coordination and integration of the sympathetic nervous and endocrine systems. Muscle contraction increases the uptake of blood glucose into the muscles, although blood glucose levels are usually maintained by glucose production through the processes of glycogenolysis and hepatic gluconeogenesis and the recruitment of other fuels, including free fatty acids (Spanoudaki et al., 2025). Several factors influence the use of fuel sources during exercise, of which the most important are the intensity and duration of the activity. Physical activity causes a substrate shift from free fatty acids (the predominant fuel at rest) to glucose, muscle glycogen, fat, and to a lesser extent, amino acids (Mason et al., 2024). As exercise intensity increases, reliance on carbohydrates (found in the blood and muscle) increases. Early in exercise, glycogen provides a large amount of fuel for the working muscle, as glycogen stores are depleted and glucose uptake from the blood and fatty acids released from adipose tissue increase. Intramuscular fat stores are a more accessible source of fuel than fat during prolonged exercise. As exercise duration continues, glucose production shifts from hepatic glycogenolysis to gluconeogenesis. On the other hand, exercise can control blood sugar and reduce hemoglobin A1c in patients with type 2 diabetes (Qin et al., 2024). However, the type of activity, intensity, duration, and frequency of exercise are important factors in diabetic patients. In a review study, Zanuso and colleagues showed that aerobic exercise resulted in greater reductions in HbA1c, increases in VO2max, and greater increases in insulin sensitivity, while resistance exercise could help control blood sugar. However, combined exercise resulted in greater changes in HbA1c than aerobic and resistance exercise alone (Thomson et al., 2024). Other studies have shown that high-intensity exercise training has a greater effect on insulin sensitivity and improvement in type 2 diabetes (Zafarmand et al., 2024). Therefore, during moderate-intensity exercise in nondiabetic individuals, increased glucose uptake by peripheral skeletal muscle tissues is consistent with increased hepatic glucose production. The result is that blood glucose does not change during prolonged exercise in individuals with type 2 diabetes. During moderate exercise at 45 to 75% of maximum heart rate, muscle glucose utilization increases more than hepatic glucose production, and blood glucose levels decrease as a result. Plasma insulin levels naturally decrease, so the risk of hypoglycemia during prolonged exercise in individuals not receiving insulin or insulin agonists is negligible. The effects of a single bout of aerobic exercise on insulin action vary with duration, intensity, and subsequent diet. However, a single bout of aerobic exercise improves insulin action and glucose tolerance for 24 to 48 hours (Mennitti et al., 2024). On the other hand, during intense and short-term aerobic exercise, plasma catecholamine levels increase significantly, which leads to an increase in glucose production (Soori & Zafarmand, 2024). Therefore, in such activities, an increase in blood glucose can occur and continue for 1 to 2 hours because plasma catecholamine levels and glucose production do not return to normal levels immediately after cessation of exercise. According to the presented material and despite the positive effects of different types of exercise activities on indicators related to type 2 diabetes, it is still questionable which type of aerobic, resistance, combined or interval training is more beneficial. Therefore, the aim of this study was to

investigate the effects of different types of exercise activities on indicators related to type 2 diabetes.

2. Method

The research method was descriptive-library and a search was conducted in Magiran, Google scholar, Science Direct, and PubMed databases with the keywords Insulin sensitivity, diabetes, High-intensity interval training, resistance training, exercise training, and HbA1c, resistance training, high-intensity interval training, aerobic training, combined exercise, type 2 diabetes, and insulin sensitivity to retrieve articles published between 2010 and 2025.

3. Results

3.1. Training Methods

High-intensity interval training (HIIT) and sprint interval training (SIT) are not common terms among the general public as a type of exercise, but sports science experts and clinical science experts note that the use of high-intensity interval training (explosive) can have more beneficial effects on improving the performance of athletes, increasing the physical fitness of healthy people, the time of activity, and also the treatment and rehabilitation of some diseases compared to long-term moderate-intensity exercise (Joseph et al., 2021). HIIT includes explosive, intense, short, and intermittent activities with low-intensity recovery periods (maintaining the training process but at a low intensity). In recent years, the use of the HIIT program has become popular and is perhaps the most efficient method of exercise in relation to the time spent. In this regard, Alizadeh et al. showed that HIIT training reduces insulin, glucose, Hba1c and HOMA index levels in women with type 2 diabetes (Alizadeh et al., 2019). Research showed that speed interval training (SIT) has a significant effect on reducing fasting glucose, insulin resistance and fasting insulin in women with type 2 diabetes (Fex et al., 2015). In another study, Medsen et al. showed that 8 weeks of HIIT training improves fasting blood glucose indices, HOMA IR and insulin sensitivity in elderly patients with type 2 diabetes (Madsen et al., 2015). FEX et al. showed in their study that 12 weeks of intense interval training reduces fasting blood glucose, Hba1c and body composition in patients with type 2 diabetes (Fex et al., 2015). In another study, Najafi et al. showed that 12 weeks of HIIT training significantly reduced insulin resistance, insulin levels, and glucose in middle-aged patients with type 2 diabetes (Najafi et al., 2020). The mechanism by which intense exercise improves insulin sensitivity is not clear. However, most of the environmental adaptations following an intense exercise program are likely related to enzymatic changes in muscle cells, and the molecular mechanism and enzymatic adaptations are attributed to the activation of a protein called adenosine monophosphate-activated protein kinase (AMPK) (Gibala et al., 2014). This protein is one of the possible mechanisms for increasing glucose entry into cells, especially muscle cells, during an intense exercise program, which increases insulin sensitivity (Saremi et al., 2010). Based on the results of studies conducted in this field, it has been well shown that each session of intense intermittent exercise leads to a significant increase in the activity of this signaling protein, which is similar to other long-term continuous activities, and researchers have attributed the most important factor in the activation of this protein to changes in the ratio between the concentration of adenine nucleotides inside the cell (Oliveira et al., 2012). In this regard, it has been reported that intense exercise causes rapid and sudden changes in this ratio and is an important factor in the activation of the AMPK protein (Saremi et al., 2010). Also, the improvement in insulin sensitivity in intense exercise may be related to the recruitment of muscle fibers or the reduction of glycogen in the muscle, which causes glucose absorption by skeletal muscle in the hours after exercise (Durrer et

al., 2015). High-intensity interval training can be comparable to endurance training in inducing microscopic adaptations, which can improve insulin levels and glucose delivery to skeletal muscle and lead to increased insulin sensitivity (Durrer et al., 2015). Studies have also reported that increased insulin sensitivity after intense exercise can be due to PGC-1α expression and AdipoR1 (Adiponectin receptor 1) gene expression levels (Za'don et al., 2019). Accordingly, it seems that high-intensity interval training, while increasing AMPk activation, increases glucose entry into active muscle cells, and this type of exercise, while increasing PGC-1α expression, increases insulin sensitivity, which can lead to increased glucose uptake in skeletal muscle in the hours after exercise.

3.2. Aerobic exercise

The results of numerous studies on the effects of aerobic exercise on patients with type 2 diabetes have shown that lifestyle changes and increased exercise, especially aerobic exercise, can be beneficial in improving diabetes-related indicators and increasing insulin sensitivity in people with type 2 diabetes and preventing type 2 diabetes in healthy people. Accordingly, Momeni and colleagues concluded in a study that aerobic exercise has a significant effect on reducing glucose, fasting blood insulin, and insulin resistance in men with type 2 diabetes (Arabmomeni & Haji Hidari, 2019). Kadoglou and colleagues also showed in their study that 12 weeks of aerobic exercise has a significant effect on improving insulin indicators, HOMA-IR, and Hba1c in patients with type 2 diabetes (Kadoglou et al., 2012). Shakarian and colleagues concluded in a study that this type of exercise reduces serum insulin and insulin resistance in women with type 2 diabetes (Motallebi et al., 2016). Aly and colleagues also showed in a study on 35 men with type 2 diabetes who had been suffering from this disease for more than 5 years that performing 12 weeks of aerobic exercise significantly reduced fasting blood sugar, HbA1c, and insulin resistance (Aly et al., 2014). In another study, Mardani and colleagues showed that performing moderate-intensity aerobic exercise for 8 weeks reduced HOMA-IR fasting glucose and insulin levels in women with type 2 diabetes (Mardani et al., 2022). Shakil and colleagues also found in a study on 102 diabetic men and women that 25 weeks of aerobic training improved insulin resistance indices, fasting blood glucose, blood sugar and plasma insulin in these patients (Shakil-Ur-Rehman et al., 2017). In another study, Omidi and colleagues showed that 8 weeks of aerobic training for 30-40 minutes at moderate intensity reduced fasting glucose, fasting insulin and insulin resistance index in middle-aged women with type 2 diabetes (Omidi & Moghadasi, 2018). Research on the number of aerobic training sessions stated that at least 3 days a week or 48 hours of rest between training sessions should be performed. In most clinical studies, exercise interventions in people with type 2 diabetes are three days a week (Egger et al., 2013; Mardani et al., 2022). However, recent recommendations emphasize the completion of 5 sessions of moderate aerobic activity (Samadpour Masouleh et al., 2022). Regarding the intensity of aerobic exercise, researchers stated that it should be performed at a moderate intensity, that is, about 40-60% of maximum aerobic capacity (Vo2max). For most people with type 2 diabetes, brisk walking is considered a moderate-intensity exercise. However, greater benefits are obtained by increasing the intensity of exercise (more than 60% of Vo2max) (Church et al., 2010). In this regard, a meta-analysis showed that exercise intensity is more important than exercise volume in improving blood glucose control, suggesting that people who have been doing moderate exercise for a long time should perform weekly exercise sessions with higher intensity to gain more benefits from exercise (Liu et al., 2015). On the other hand, the duration of exercise for people with diabetes should be at least 150 minutes per week of moderate-intensity exercise. Performing 150 minutes of moderate-to-vigorous exercise per week is associated with a decrease in mortality in people with diabetes (Samadpour Masouleh et al., 2022). The American College of Sports Medicine recommends 150 minutes of moderate-intensity activity (30 minutes per day, 5 days per week) or 60 minutes of vigorous-intensity activity (30 minutes per day,

3 days per week) to improve blood glucose control and cardiovascular function in adults with diabetes (Ansari et al., 2017). According to the results of various studies, it seems that aerobic exercise improves indicators related to type 2 diabetes through different mechanisms. Several studies have shown that aerobic exercise can reduce HbA1c levels by up to 66% by reducing fat percentage and improving blood glucose in patients with type 2 diabetes (Motallebi et al., 2016). It has also been shown that aerobic exercise improves oxygen consumption and can be effective in reducing blood glucose and HbA1c (Church et al., 2010). Aerobic exercise can improve insulin sensitivity, insulin resistance, and fasting glucose in patients with type 2 diabetes by increasing insulin reuptake signaling, increasing GLUT-4 gene expression [37], increasing glycogen synthase and hexokinase activity, decreasing the release and increasing the clearance of free fatty acids, increasing the release of glucose from the blood to the muscle due to increased muscle capillaries, and changing muscle composition for glucose uptake (Church et al., 2010; Jia et al., 2024; Joseph et al., 2021). It can improve indices of insulin sensitivity, insulin resistance, and fasting glucose in patients with type 2 diabetes. It also seems that aerobic exercise, by creating its own specific biochemical changes in muscles, increasing capillary density and increasing oxidative enzymes, can improve the process of glucose transport and metabolism and increase the capacity of insulin binding to muscle cell receptors, which as a result reduces the need for insulin (Fex et al., 2015). Accordingly, aerobic exercise, by increasing mitochondrial capacity and improving oxygen consumption, while increasing fat metabolism, leads to a decrease in HbA1c and blood glucose. On the other hand, this type of exercise, by increasing GLUT-4 transport to the membrane surface and increasing glycogen synthase and hexokinase activity, reduces insulin resistance and reduces fasting glucose in patients with type 2 diabetes. Resistance exercise: Since skeletal muscle is the main site of glucose uptake in the normal state, resistance exercise with muscle contractions has insulin-like effects on glucose uptake in skeletal muscle. Therefore, it can be assumed that increasing muscle mass is an effective method in improving indicators related to type 2 diabetes. In this regard, Durrer et al. reported that resistance training has a significant effect on reducing fasting plasma glucose, postprandial plasma glucose, insulin resistance, and HbA1c (Durrer et al., 2015). Egger et al. also showed in a study that 8 weeks of resistance training at an intensity of 70% of one repetition maximum improved glucose and HbA1c levels in 32 men and women with type 2 diabetes (Egger et al., 2013). Nazari et al. stated in a study that resistance training at an intensity of 40 to 65% of one repetition maximum reduced HbA1c in 20 women with type 2 diabetes but had no significant effect on fasting blood sugar (Nazari et al., 2016). Afshounpour and colleagues concluded in a study that resistance training for 8 weeks at an intensity of 30 to 70% of one repetition maximum reduced insulin, blood glucose, glycosylated hemoglobin, and insulin resistance index in men with type 2 diabetes (AfshounPour et al., 2015). (Church et al., 2010). Taji Tabas and colleagues also showed in a study that resistance training significantly reduced glucose and insulin resistance in women with type 2 diabetes, but had no significant effect on insulin levels (Taji Tabas & Mogharnasi, 2015). Miri and colleagues concluded in a study that resistance training had a significant effect on improving Hba1c in men with type 2 diabetes (Taji Tabas & Mogharnasi, 2015). This type of training increases insulin sensitivity and improves glycemic control by increasing muscle mass and strength (Ansari et al., 2017). Therefore, it seems that muscle functional capacity increases with increasing muscle volume after resistance training, and this factor increases insulin sensitivity in skeletal muscle. Resistance training also significantly activates AMPK and increases intramyocellular triacylglycerol (IMTG) (Koopman et al., 2005). Regarding the number of resistance training sessions, researchers stated that at least 2 sessions per week (of course, 3 sessions are better) should be performed along with aerobic training, meaning that a combination of resistance and aerobic training in each training session leads to greater improvement in insulin sensitivity (Joseph et al., 2021; Kadoglou et al., 2012; Knaga & Buresh, 2022; Koo et al., 2021).

Research on the intensity of resistance training has shown that resistance training should be performed at moderate intensity (50% of one repetition maximum, the maximum weight that can be lifted once) or vigorous intensity (75-80% of one repetition maximum) to achieve the optimal goal of strengthening muscle strength and improving insulin action. Home strength training, which is less supervised by a sports science specialist, although effective in maintaining strength and muscle mass, has little effect on blood glucose control (Ramezani et al., 2023). There is an important issue here; the duration, intensity and frequency of training affect both the heart rate and the athlete's health and performance. The planning of the training is important in this respect. Studies show this (Serin and Taşkın, 2016; Serin; 2018; Serin, 2019; Serin, 2020). Also, the duration of each training session should be at least 5 to 10 movements that include the large muscles of the upper and lower torso, and each movement should be repeated between 10 and 15 times per set. Start training with at least one set, which should gradually increase to 3 sets to gain greater benefits on insulin action (Oliveira et al., 2012; Omidi & Moghadasi, 2018; Ramezani et al., 2023). In this regard, based on the results of hypertrophy studies, muscle fibers are also of great importance; because insulin-sensitive muscle fibers contain greater oxidative and mitochondrial capacity and higher capillary density, and as a result, muscle hypertrophy due to resistance training increases insulin sensitivity throughout the body (Sadighi et al., 2024).

4. Discussion

One of the main axes of diabetes management and prevention is physical activity. Various studies have shown that physical exercise improves indicators related to type 2 diabetes by increasing energy expenditure and improving muscle mass. On the other hand, the immediate effects of exercise and physical activity on fuel metabolism during exercise, maintaining normal blood glucose during rest and exercise depend on the coordination and integration of the sympathetic nerves and the endocrine system. Muscle contraction increases the absorption of blood glucose into the muscles, although blood glucose levels are usually maintained through the production of glucose through the process of glycogenolysis and hepatic gluconeogenesis and the call of other fuels, including free fatty acids, which lead to the use of fuel sources during exercise effectively (Darvishi et al., 2024; Durrer et al., 2015; Egger et al., 2013; Enteshary et al., 2018), of course the most important of which are the intensity and duration of the activity. Physical activity causes a substrate shift from free fatty acids, the dominant fuel at rest, to glucose, muscle glycogen, fat, and to a lesser extent amino acids. As exercise intensity increases, reliance on carbohydrates in the blood and muscle increases. Early in exercise, glycogen provides a large volume of fuel for the working muscle, as glycogen stores are depleted and glucose uptake from the blood and fatty acids released from adipose tissue increase. Intramuscular fat stores are a more available source than fat during prolonged exercise. As exercise duration continues, glucose production shifts from hepatic glycogenolysis to gluconeogenesis. Therefore, research has shown that exercise improves diabetes-related markers through various signaling pathways. One of these pathways is the improvement of the insulin-dependent transporter GLUT4, which has been mentioned in all studies, and its expression is higher in adipose tissue and skeletal muscle. Increasing GLUT4, mainly through physical activities and also Insulin receptor substrate (IRS), which is an insulin receptor, leads to higher insulin secretion and increased muscle mass in the body (Cunha et al., 2015). Also, increasing Adenosine Monophosphate-activated Protein Kinase (AMPK), which is activated following an increase in the AMP/ATP ratio, is considered a key intracellular signaling pathway in glucose uptake. Another signaling pathway that can be attributed to glucose uptake is the increase in calcium-dependent calmodulin kinase due to exercise and muscle contractions (Cunha et al., 2015; Liu et al., 2015; Madsen et al., 2015; Mafhoom et al., 2024). The results of the studies have shown

that 3 hours after exercise, GLUT4 translocation increased, which researchers have stated as the effective mechanism for the increase in GLUT4 is due to the activity of AMPK as an activator of the TBC1 domain family gene (TBC1D1) member 1) which is effective in glucose uptake [69]. Another identified pathway is the phosphatidyl inositol kinase 3 (mTOR), protein kinase B (AKT) mammalian target of rapamycin and PI3K) Phosphoinositide 3-kinases, which leads to an increase in muscle mass and muscle strength and, as a result, muscle hypertrophy. Changes in muscle mass and volume lead to improved glucose and fat metabolism in skeletal muscles (Khavarian et al., 2021). In general, given that skeletal muscle contributes the most to whole-body insulin resistance, exercise training can improve glucose metabolism, fat, and insulin sensitivity. Studies show that insulin secretion and PI3K activity are reduced in skeletal muscle of overweight and type 2 diabetic individuals. In fact, insulin receptor substrate and PI3K are increased after exercise training, which improves insulin-induced glucose uptake. Also, increasing AMPK is another mechanism by which exercise training improves insulin sensitivity. On the other hand, the increase in AMPK caused by exercise through the terminal components of the insulin signaling cascade, namely the AKT/AS60 signaling pathway and the expression of GLUT4 protein and its transport to the plasma membrane in skeletal muscle, leads to the entry of glucose into the cell and its consumption.

5. Conclusions

Based on the results of the reviewed studies, various types of exercise training in patients with type 2 diabetes improve glycemic control indices including (HbA1c), HOMA IR), fasting glucose and serum insulin in a dose-dependent manner (intensity, duration and frequency). Also, new exercises such as high-intensity interval training (SIT, HIIT) and combination exercises can be effective in improving indices related to type 2 diabetes. However, the present study showed that the beneficial effects of resistance training compared to endurance training can be sustained for a longer period of time. Exercise plays a key role in the prevention and control of insulin resistance, prediabetes, gestational diabetes, type 2 diabetes and diabetes-related health problems. Both aerobic and resistance training improve insulin action and are effective in managing blood glucose, blood lipids, blood pressure, cardiovascular mortality risk and quality of life. Of course, it should be noted that in order to benefit from these benefits, exercise must be done regularly and continuously.

- Physical activity increases glucose uptake by active muscles, and hepatic glucose production helps maintain blood glucose. On the other hand, increasing exercise intensity increases the reliance of active muscles on carbohydrates.

- Given that glucose uptake by skeletal muscle during rest is mainly stimulated by insulin, which is impaired in diabetics, exercise and physical activity cause muscle contraction to stimulate glucose transport by improving insulin sensitivity and multiple separate mechanisms.

- Moderate-intensity aerobic exercise temporarily improves insulin action and glucose uptake by skeletal muscle. In these conditions and without the use of exogenous insulin, the risk of hypoglycemia is low, although a temporary increase in blood glucose can occur following intense physical activity. On the other hand, physical activity immediately improves insulin action, which lasts from 2 to 72 hours.

- Regarding resistance training, reports on the immediate effects of resistance training in type 2 diabetics are limited, but in prediabetic individuals, one session of resistance training leads to a decrease in blood glucose for 24 hours.

- Bodybuilding machines and free weights are among the tools that can be used to improve strength and muscle mass in diabetics. Of course, free weights and bodybuilding machines are more effective in controlling blood glucose and insulin action.

- In addition to aerobic exercise, people with type 2 diabetes should do 2 to 3 sessions of moderate to intense resistance training (at least 6 repetitions for each movement) per week. It is recommended that aerobic and resistance training be performed together. Performing 3 sessions of combined training per week in people with type 2 diabetes is more effective in controlling blood glucose than aerobic or resistance training alone. However, the total duration of training and calories consumed in combined training are greater than either exercise alone.

Declaration of Conflicting Interests and Ethics

The authors declare no conflict of interest.

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