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Research Paper

The Effect of physical Exercise on Blood Sugar Levels, Insulin Hormones and Cortisol Hormones in Type II Diabetes Mellitus Patients: A Review Study

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ABSTRACT:*Lifestyle is responsible for the greatest incidence of type 2 diabetes mellitus. Efforts are necessary to prevent it., Physical exercises are human activities that carry out movements based on certain techniques, where the implementation has an element of play, can be fun, done in spare time, and gives satisfaction to those who demonstrate it. Integrating exercise into daily life has helped to reduce mortality and prevent diabetes and high blood pressure. Patients with diabetes mellitus who exercise regularly will improve their insulin tolerance for blood glucose and helps control blood sugar, which will increase insulin and cortisol hormones. This literature review aims to describe and deepen studies on the effect of physical exercise on blood sugar levels, insulin hormones, and cortisol hormones in type II diabetes mellitus patients. The methodology used in this study is to gather and analyze data on the effect of physical exercise on blood sugar levels, insulin hormones, and cortisol hormones in type II diabetes mellitus patients. Articles are sourced from the Google Scholar database, PubMed, and Pediatric Research. The keywords used are physical exercise, blood sugar, type II diabetes mellitus, insulin hormones, and cortisol hormones.*

KEYWORDS:*Physical Exercise, Blood Sugar level, type II diabetes mellitus, insulin, cortisol hormones*

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I. INTRODUCTION

Lifestyle is responsible for the greatest incidence of type 2 diabetes mellitus. Patients with diabetes mellitus are a chronic disease that cannot be cured, but their blood sugar levels can be stabilized at normal levels through appropriate and proper treatment [1]. Patients with diabetes mellitus who exercise regularly will improve their insulin tolerance for blood glucose [2]. Physical exercise helps control blood sugar in people with type 2 diabetes mellitus [3].

Physical exercise are human activities that carry out movements based on certain techniques, where the implementation has an element of play, can be fun, done in spare time, and gives satisfaction to those who demonstrate it. A balanced physical and psychological condition should sustain this extremely high routine. The balance of physical and psychological conditions can be achieved through human exertion through sport and leisure activities to reduce mental tension[4].

The risk factors for cardiovascular disease are high cholesterol, hypertension, diabetes, obesity and smoking. Lack of exercise tends to exacerbate the harmful effects of these risk factors, whereas incorporating exercise into the daily routine has been shown to reduce mortality. In particular, lack of exercise is directly related to obesity while playing a role in the onset of diabetes and high blood pressure[5, 6].

Physical exercise that is carried out correctly, directed and regularly will be beneficial in increasing the body's muscle endurance and inhibiting or slowing down the decline due to suffering from an illness or advancing age.The evidence on the health benefits of physical activity is compelling and plays an important role in the primary and secondary prevention of coronary heart disease. A sedentary lifestyle is a significant modifiable risk factor for cardiovascular morbidity and death. Moderate levels of work or recreation also provide a significant protective impact[7].

Physicalexercise training for patients with coronary artery disease is usually known as cardiac rehabilitation. But exercise is only one component of what's called post-release cardiac intensive care. The objective of this program is to restore optimal physical, psychological, social, emotional, occupational and economic conditions for patients with heart disease. Short-term goals include physical rehabilitation, education about the disease process, and emotional support during the initial phase of recovery. Long-term objectives include managing risk factors and teaching a healthy lifestyle that improves prognosis and physical status for an earlier return to work[8].

II. METHOD

The method used in this study is to collect and analyze data on physical Exercise on Blood Sugar Levels, Insulin Hormones, and Cortisol Hormones in Type II Diabetes Mellitus Patients. The articles reviewed were sourced from the Google Scholar database, PubMed, and Pediatric Research. Keywords include physical Exercise, Blood Sugar Levels, Insulin Hormones, Cortisol Hormones, and Type II Diabetes Mellitus.

III. DISCUSSION

Sports are human activities that carry out movements based on specific techniques, where the implementation has an element of play, can be fun, done in spare time, and gives satisfaction to those who demonstrate it. A balanced psychological and physical body condition must support this very high routine. The balance of physical and psychological conditions can be achieved by human effort through sports and recreational activities to reduce tensions in mind (refreshing and relaxing)[4].

Physical training for patients with CD is typically called cardiac rehabilitation. Still, exercise is only one component of what is referred to aspost-discharge intensive cardiac care. This program aims to return heart disease patients to optimal physical, psychological, social, emotional, vocational, and economic conditions[8].

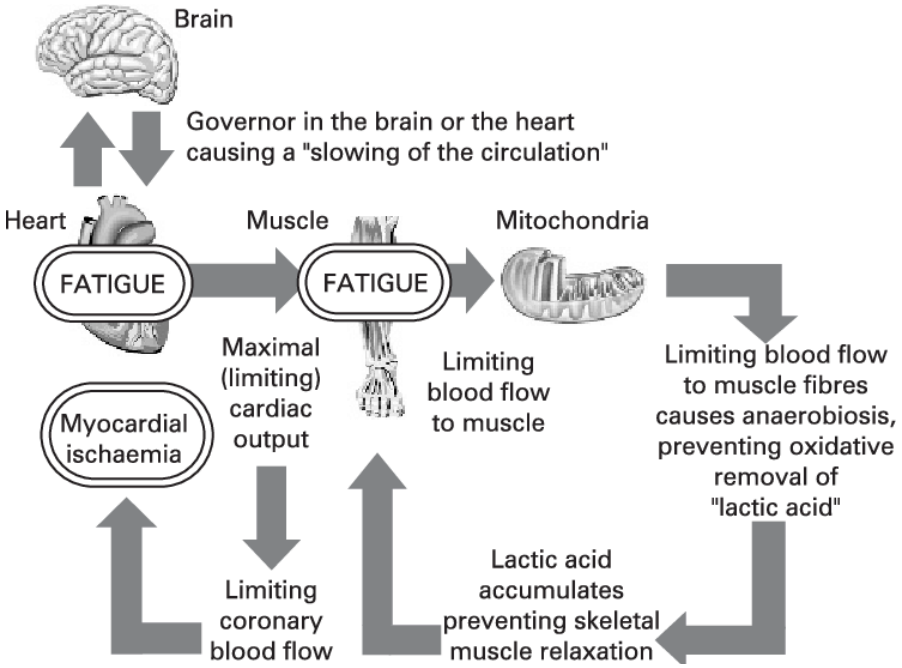

Figure 1. The physiology of human physical activities[9]

The musculoskeletal system is at the forefront of sports activities. The three types of muscle fibers have different characteristics. Higher myosin ATPase activity is directly proportional to faster muscle contraction speed, while higher oxidative capacity is associated with fatigue. Type-I fibers are known as slow-twitch fibers. These fibers have abundant mitochondria and myoglobin with a sizeable vascular supply. They have low myosin ATPase activity, high oxidative, and low glycolytic capacity. These muscle fibers are fatigue resistant and predominant in postural muscles because they provide low strength but do not fatigue as quickly as the others[10].

Type-IIa fibers are known as fast-twitch oxidative fibers. They have high myosin ATPase activity and oxidative and glycolytic capacity. These fibers are relatively fatigue-resistant and are recruited for strength-intensive activities for sustained efforts, such as lifting weights for multiple repetitions. Type-IIa fiber is an intermediate type between the slow but fatigue-resistant type-I fiber and the fast but fatigue-resistant type-IIb fiber. Type IIb fibers are known as fast-twitch glycolytic fibers. They have high myosin ATPase activity, low

oxidative, high glycolytic activity, and fatigue quickly. These fibers are recruited for high-intensity, short-duration exercises such as full-effort sprints[10].

Blood Sugar Levels

Aerobic exercise and resistance improve glycemic control to a degree comparable to certain oral diabetes medications. Some data suggest that exercise duration and intensity affect HbA1c levels. A meta-analysis of randomized controlled trials with a minimum duration of 12 weeks concluded that >150 minutes per week of structured exercise resulted in a more significant decrease in HbA1c (−0. 89%) compared to those who exercised less (−0. 36 %)[11].

Another meta-analysis of aerobic exercise studies concluded that not only did higher exercise intensity tend to result in more significant VO2max increases, but that exercise intensity predicted postintervention HbA1c ($r = 0.91$, $P = 0.002$) better than exercise volume ($r = 0.46$, $P = 0.26$). Exercise for an average of 49 minutes (10-15 minutes warm-up and cool-down), with an average of 3 to 4 sessions per week for 20 weeks[12].Skeletal muscle is responsible for most glucose absorption after meals, and the transport of glucose into muscle is considered the limiting step in glucose elimination. Glucose transport occurs by diffusion using glucose transporter carrier proteins (GLUT). Neither exercise nor insulin regulates the transport of glucose, mainly through translocation of GLUT4 isoforms from the intracellular compartment into the plasma membrane and transverse tubules. GLUT4 levels are considered an essential determinant of insulin sensitivity[13, 14].

Insulin-induced translocation of GLUT4 is usually altered in type 2 diabetes. During exercise, muscles use the glucose provided by intra-muscular glycogenolysis and with increased glucose absorption. Aerobic exercise and resistance increase the abundance and translocation of GLUT4, hence the absorption of blood glucose through routes independent of insulin[13, 14].

Unlike those at lower intensities, glucose is the exclusive muscle fuel in patients with intense exercise (VO2 max>80%). Catecholamine levels increase markedly, causing glucose production to increase seven to eightfold, while glucose utilization increases only three to fourfold. Patients without diabetes will experience a slight increase in blood glucose during intense exercise, which rises further after fatigue and persists for up to 1 hour. Plasma insulin levels rise, correcting glucose levels and restoring muscle glycogen. This physiological response will not exist in people with type 1diabetes[14]. Physical exercise can still function to increase glucose absorption. Cytokine release during exercise or physical activity can promote adipose lipolysis and cause an increased release of fatty acids. This can further promote hepatic lipid synthesis and activate hepatic gluconeogenesis through acetyl-CoA-mediated activation of PC and glycerol (AC-CoA mediated), thus increasing glucose production through substrate boosting[15].

InsulinHormone

Insulin is produced in pancreatic islet beta cells as preproinsulin, then converted to proinsulin by cleavage of its N-terminal signal peptide by microsomal enzymes and stored in zinc-bound crystals as secretory granules after packaging by the Golgi apparatus. Mature insulin is produced by proteases that reside in the same storage vesicles as proinsulin. This causes the secretory granules attached to the cell membrane to be prepared for insulin exocytosis in response to a circulatory stimulus[16].

Insulin release is stimulated by glucose penetrating the liver beta cells by facilitated diffusion of GLUT-2. Within the beta cells, glucose is phosphorylated to G6P by glucokinase activity, which is considered a "glucose sensor" because it controls the rate of glucose retention in the beta cells, which contains the rate of insulin release. Synthesis of adenosine triphosphate (ATP) by G6P in beta cells increases the ratio of ATP/adenosine diphosphate (ADP), which closes ATP-sensitive K+ channels, thereby depolarizing the beta cell membrane and increases intracellular calcium levels by opening voltage-gated Ca2+ channels[10].

Previous studies reported that exercise training reduced insulin resistance. Research shows that three months of aerobic exercise improves beta-cell function in T2DM, and a 12-week exercise intervention improves beta-cell function in older obese adults and patients with T2DM. Individuals exercising 150 minutes per week showed a significant (−0.89%) decrease in HbA1c compared to those exercising <150 minutes. Another systematic review and meta-analysis investigating the effects of short-term (≤2 weeks) exercise training on glycemic control, as measured by continuous glucose monitoring in T2DM, showed that exercise significantly reduced hyperglycemia (>10.0 mmol/L) but did not considerably alter fasting blood sugar levels[17].

Several studies that found significant improvements in glucose tolerance and insulin sensitivity in response to exercise achieved post-training measurements within 12 to 48 hours of the last exercise session. This is confirmed by the fact that stopping exercise in trained individuals is associated with a marked and rapid decline in insulin sensitivity. The authors note that a single moderate exercise can increase glucose intake by as much as 40%. In addition, exercise supports weight loss, which reverses insulin resistance, which is characteristic of obesity[18].

The beneficial impact of daily exercise on insulin resistance is magnified when a decrease in body fat accompanies it. It is an effective therapeutic strategy to reduce insulin resistance and, most importantly, enhance quality of life and overall well-being. Individuals with diabetes due to insulin resistance can recover with physical exercise habits. Glucose absorption remains elevated for up to 120 minutes after exercise due to the increased presence of GLUT4 in the plasma membrane and T-tubes. Insulin sensitivity rises for at least 16hours after exercise. This happens in healthy people and people with type 2 diabetes. Physical activity can also lead to beneficial changes in lipid metabolism and regulate the level of liver glucose, which is essential in type 2 diabetes[18].

Cortisol Hormones

Cortisol is a steroid hormone that is synthesized from cholesterol. Cortisol is synthesized in the zona fasciculata layer of the adrenal cortex. Adrenocorticotropic hormone (ACTH) released from the anterior pituitary functions to increase LDL receptors and increase cholesterol desmolase activity, thus converting cholesterol into pregnenolone and is the rate-limiting step of cortisol synthesis. Most of the circulating glucocorticoids are inactive, bound either to corticosteroid-binding globulin (CBG) or albumin. The inactive form is converted to the active form by 11-beta-hydroxysteroid dehydrogenase 1 (11-beta-HSD1) in most tissues, whereas 11-beta-HSD2 deactivates cortisol back into cortisone in the kidney and pancreas[19].

Blood glucose leads to key systemic and intracellular routes. The presence of glucocorticoids, such as cortisol, may improve the availability of blood glucose in the brain. Cortisol has an effect on the liver, muscles, fat and pancreas. Elevated levels of cortisol in the liver can increase gluconeogenesis and reduce glycogenic synthesis. Gluconeogenesis is the metabolic pathway that produces glucose from the glucogenic amino acid, lactate and glycerol 3-phosphate found in triglycerides[19].

Cortisol in adipose tissue can increase lipolysis. Lipolysis is a catabolic process which translates into the release of glycerol and free fatty acids. These free fatty acids may be used in oxidation B and as an energy source for other cells as they continue to produce glucose. Lastly, cortisol acts on the pancreas to lower insulin and increase glucagon. Glucagon is a peptide hormone secreted from alpha pancreatic cells to increase hepatic glycogenolysis, hepatic gluconeogenesis, hepatic ketogenesis, and lipolysis and decrease lipogenesis. Cortisol increases the activity of glucagon, epinephrine, and other catecholamines[19].

A study examined the effect of exercise intensity on the HPA axis cortisol response during 30 minutes of exercise at VO2 max intensities of 40, 60, and 80% to determine which intensity causes an increase in hormonal circulation. Their findings support the concept that moderate to high-intensity exercise (60% and 80%) triggers a significant increase in circulating cortisol. This increase appears to be due to a combination of hemoconcentration and enhanced secretory stimulation (i.e., ACTH) on the HPA axis. In contrast, low-intensity exercise (40%) did not significantly increase circulating cortisol levels. The implementation intensity of 50% was increased to 120 minutes, there was still no significant increase in cortisol levels. The lack of agreement between these studies and those that have not seen any improvement with exercise or improvement only at very high exercise intensities may be due to several factors. One of these factors is the background of sports training. Those with more training usually have a higher intensity threshold necessary to trigger an increase in cortisol[20].

As assessed by reported levels of VO2max, exercise levels within the subject appear to vary significantly from one study to the next. Another important factor affecting hormone results is the length of the blood collection protocol. Studies report that the time blood samples are collected concerning exercise (immediately at the end, 10 minutes, 20 minutes into recovery, etc.) can greatly influence the interpretation of the outcome data due to the hormonal half-of-life[20].

IV. CONCLUSION

Patients with diabetes mellitus are a chronic disease that cannot be cured, but their blood sugar levels can be stabilized at normal levels. Patients with diabetes mellitus who exercise regularly will improve their insulin tolerance for blood glucose. Physical exercise helps control blood sugar in people with type 2 diabetes mellitus [3]. Duration and intensity of exercise affect HbA1c levels. Physical exercise >150 minutes per week of structured exercise resulted in a more significant decrease in HbA1c (−0. 89%) compared to those who exercised less (−0. 36 %). Furthermore, exercise training reduces insulin resistance and significantly reduces hyperglycemia (>10.0 mmol/L). Several studies stated that the effect of exercise moderate to high intensity (60% and 80%) triggers a significant increase in circulating cortisol.

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