PHYSICAL EXERCISE REDUCES INSULIN HORMONE SECRETION AND INCREASES GLUCAGON HORMONE SECRETION: A SYSTEMATIC REVIEW

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Abstract

The purpose of this study is to investigate and quantify the impact of exercise on insulin and glucagon levels. Employing a systematic approach, this research delves into various journal databases including Embase, PubMed, Web of Science, and Scopus. Criteria for inclusion in this study encompass articles on physical activity, insulin, glucagon, their mechanisms, and publications from the past five years. Only articles from anonymous journals are considered for inclusion. A total of 12,380 articles were identified from Embase, Web of Science, PubMed, and Scopus databases. Approximately ten articles meeting the criteria for this systematic review were thoroughly examined and analyzed. The study adhered to the reporting guidelines outlined in the PRISMA checklist for Systematic and Meta-Analysis. Findings from this systematic review analysis reveal a decrease in insulin secretion and an increase in glucagon production following physical exercise. This is associated with enhanced insulin sensitivity and increased glucose absorption by glucagon post-exercise. Incorporating physical exercise into one's routine is recommended as a proactive measure to enhance insulin sensitivity, elevate glucagon levels, promote glucose synthesis, mitigate energy imbalances, and uphold overall health.

Keywords: *Physical Exercise, Insulin Hormone, Glucagon Hormone, Systematic Review*

1. INTRODUCTION

The World Health Organization has classified type 2 diabetes mellitus as a major danger to world health since it is characterized by the body experiencing hyperglycemia as a result of the hormone insulin being lost (Care & Suppl, 2022). The International Diabetes Federation projects that while the percentage of people with diabetes mellitus will be 10.5% in 2021, it will increase to 11.3% in 2030 and 12.2% in 2040 (Ye et al., 2023). The 45 to 64 year age range has the greatest prevalence of diabetes mellitus, with more males than women in this age group, based on information from the US Census Bureau and the 2018 National Health Interview Survey (Alqadi, 2024). Prior research has directly presented epidemiological data, such as incidence rates, death rates from the Global Burden of Disease (GBD) 2019 database, together with years adjusted for disability. Furthermore, during the course of the previous 30 years, patterns in the rates of death and incidence from diabetes mellitus have been noted and assessed, along with projections of growing yearly percentage changes (Zhu et al., 2022).

A major public health concern and worldwide epidemic is physical inactivity (Dagdeviren et al., 2024). According to the 2010 WHO study, inactivity is among the top four causes of mortality from illness globally, accounting for over 3.2 million deaths annually. Previous research indicates that because of fast urbanization and changes in sociodemographics, the incidence of physical inactivity differs greatly across industrialized and developing nations (Enyew et al., 2023). Acute and chronic diabetes

mellitus complications are of the main reasons for morbidity and death globally, with virtually pandemic levels of complications (Dagdeviren et al., 2024). According to a cross-sectional research employing a kohort longitudinal sample of 1.518 people with type 2 diabetes and 6.840 people with type 1 diabetes, people between the ages of 15 and 19 are more likely to have type 2 diabetes (Pastore et al., 2020).

Insulin and glucagon are significant peptide hormones linked to diabetes mellitus and obesity (Andersen & Holst, 2022). Along with its opposing hormone, glucagon, insulin plays a critical function in the metabolism of carbohydrates by ensuring that the body's blood glucose equilibrium is maintained (Król et al., 2023). Since practically all organs depend on blood glucose for proper operation, abnormalities in the production or secretion of insulin can lead to the development of a number of illnesses, including diabetes mellitus and insulin resistance (Rahman et al., 2021). An increasing number of people in today's healthcare system are obese. Numerous additional illnesses, such as insulin resistance and diabetes mellitus, are linked to it (Zatterale et al., 2020).

Exercise is crucial for optimizing physical function and has been shown to lengthen the duration that patients survive after being diagnosed with and treated for metabolic syndrome (Newsome et al., 2024). Exercise has been shown to be both safe and practical, and its advantages include a higher quality of life and less weariness (Young et al., 2023). Long-term physical exercise has also been demonstrated to dramatically enhance the overall quality of life and blood glucose management of individuals with diabetes mellitus (Almuraikhy et al., 2023). Frequent exercise has also been shown to improve blood glucose levels in circulation, pulmonary and cardiovascular function. Moreover, it can improve endothelial function, aerobic capacity, and muscle strength (Almuraikhy et al., 2023). It has been demonstrated that exercise increases insulin sensitivity (Lin et al., 2022). Moreover, exercise can raise the hormone glucagon secretion, which is necessary for energy balance (Jensen et al., 2023). But the fundamental process is still unknown. Thus, the effect and method of physical exercise to raise the sensitivity of the insulin hormone by decreasing its production and raising the secretion of glucagon hormone will be covered in this comprehensive analysis.

This study aims to investigate and quantify the impact of exercise on insulin and glucagon levels, seeking to understand the physiological changes induced by physical activity and how these alterations affect the regulation of these critical hormones involved in glucose metabolism.

2. RESEARCH METHODS

This study involves searching multiple journal databases, including PubMed, Embase, Web of Science, and Scopus, as part of a systematic review methodology. The inclusion criteria encompass studies published within the past five years that address insulin hormone, glucagon hormone, physical activity, and exercise. The exclusion criteria exclude publications from journals with a low reputation.

2.1. Research Procedure

Complete texts, abstracts, and article titles were verified, approved, and input into the Mendeley database. Using the databases Embase, Web of Science PubMed, Scopus, and Web of Science, a total of 12.380 publications were located in the first phase. The

adequacy of the title and abstract was the basis for screening 6621 articles in the second step. Forty-two pieces were confirmed for additional processing in the third step. We now filter depending on whether the entire content is appropriate. Ten publications that satisfied the inclusion criteria were then chosen and examined for this systematic review in the last phase. A total of 10 papers that met the inclusion criteria were selected and scrutinized for this systematic review. For standard operating procedures, this study complies with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) assessment.

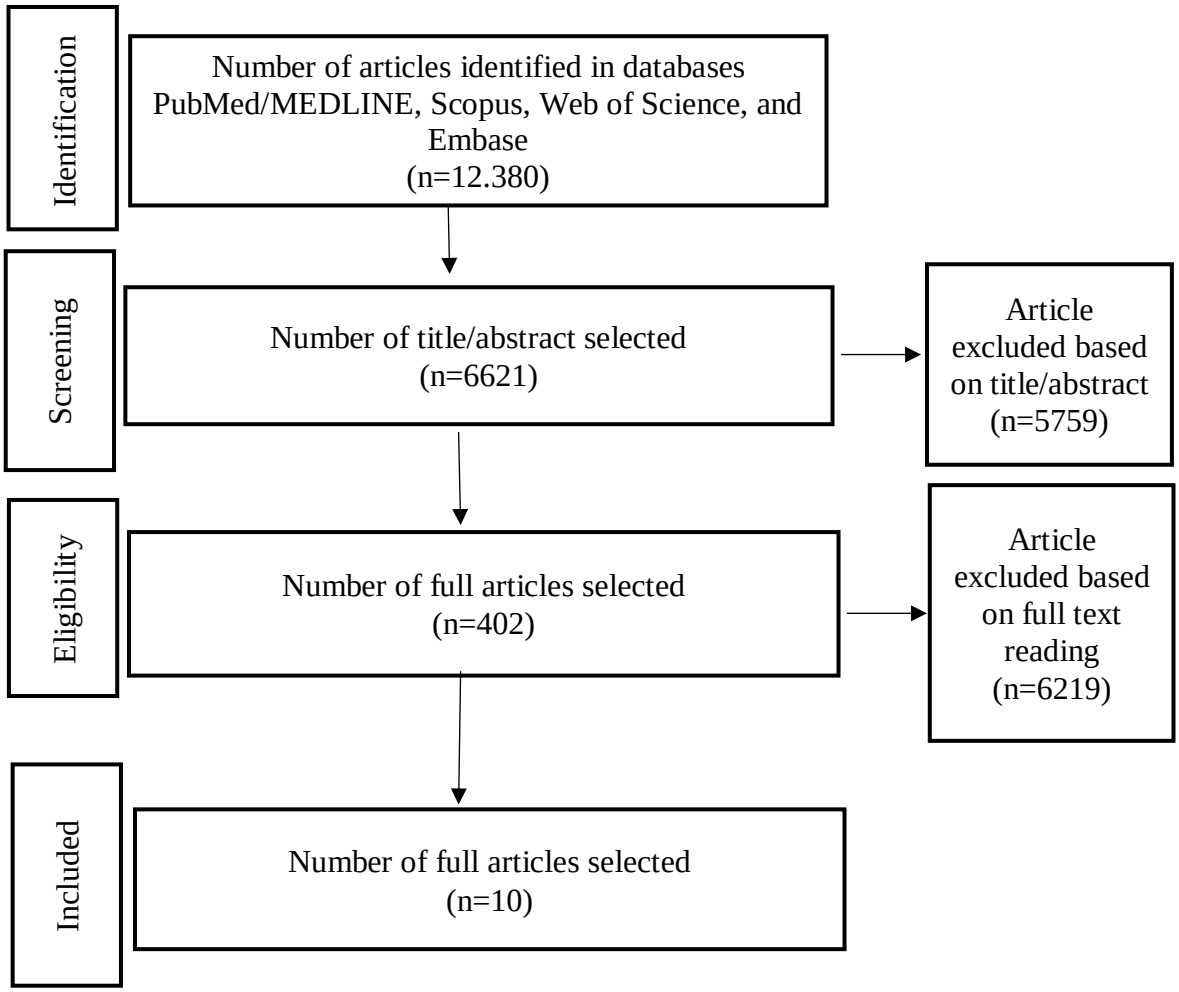

Figure 1. PRISMA Flowchart of The Article Selection Process

3. RESULTS AND DISCUSSION

3.1. Result

Table 1. Results of a Review of The Effects of Physical Exercise Reduces Insulin Hormone and Increase Glucagon Hormone Levels

Author	Sample Characteristics	Study Design	Intervention	Results
(Kristensen et al., 2023)	14 adults (11 women, 3 men) participated in this study and were divided into 2 treatment groups, namely the group given low carbohydrate and high protein + exercise and the group given high carbohydrate and low protein + exercise	Experimental	45 minutes of cycling exercise with a training intensity of 60% VO2 Max	There was a significant increase in glucagon hormone levels in the low carbohydrate and high protein + exercise groups
(Bock et al., 2022)	13 people were involved in this research using pre test and post test methods	Experimental	Submaximal physical exercise with 60% - 70% heart rate for 30 minutes	Glucagon hormone levels increased following 30 minutes of submaximal physical activity.
(Jensen et al., 2023)	In this study, 195 participants were randomly assigned to 4 groups: the exercise plus placebo group, the liraglutide intervention group, the placebo group, and the exercise + liraglutide group.	Experimental	Physical exercise for 45 minutes, consisting of 30 minutes of indoor cycling at high intensity based on intervals and 15 minutes of interval training with a frequency of 4 days a week for 52 weeks	The glucagon hormone levels in the exercise + placebo group increased.
(Farrell et al., 2023)	This study had 18 individuals, 9 of whom were male and 9 of whom were female. They were split into 2 treatment groups: the control group and the HIIT (High Intensity Interval Training) intervention group.	Experimental	HIIT training with a duration of 20 minutes on a stationary bike three times a week for four weeks	The HIIT intervention group's glucagon hormone levels significantly increased.

Author	Sample Characteristics	Study Design	Intervention	Results
(Porter et al., 2020)	In this study, 46 participants—18 non-obese, 18 obese, and 10 obese with type 2 diabetes mellitus—were split into 3 groups.	Experimental	Treadmill exercise training for 45 minutes	The glucagon hormone levels in the obese group increased significantly.
(Ji et al., 2024)	10 adult men participated in this research, namely each sample as a control group without exercise, 40% exercise, 60% exercise and 70% exercise	Experimental	Aerobic physical training on a treadmill for 60 minutes	When exercising at a 70% intensity, there was a noticeable drop in insulin hormone levels.
(Cheng et al., 2022)	In this study, twenty-four rats were randomly allocated to three groups: regular diet, high fat diet, and high fat diet plus exercise.	Experimental	Swimming training for 60 minutes per day for 8 weeks of intervention	Insulin hormone secretion levels significantly decreased in the group that followed a high-fat diet plus exercise.
(Tee et al., 2023)	14 overweight men participated in this research and underwent 3 treatment trials	Experimental	Aerobic training for 60 minutes by cycling with a lactate threshold of 90% in conditions of normoxia, moderate hypoxia and high hypoxia	In the group experiencing mild hypoxia, there was a noteworthy reduction in the levels of insulin hormone.
(Petersen et al., 2022)	48 men participated in this study consisting of 15 obese men with type 2 diabetes, 15 obese men, and 18 thin men	Experimental	HIIT ergometer rowing and cycling training 3 x a week for 8 weeks	Insulin hormone levels significantly dropped in the group of obese individuals and those with type 2 diabetes mellitus.
(Han et al., 2023)	36 participants in all, split into two groups of 18 each—the vigor group and the moderate group—participated in this study.	Experimental	For eight weeks, the moderate group received physical exercise consisting of thirty minutes of brisk walking five times a week, while the vigorous group had fifteen minutes of high-intensity interval training (HIIT) each day.	There was a decrease in insulin hormone levels in the moderate group

3.2. DISCUSSION

In research Bock et al., 2022, demonstrated that in individuals with type 2 diabetes mellitus, plasma glucose levels rose after breakfast and fell during the recovery period following acute aerobic activity for up to 90 minutes. Exercise can substantially raise blood glucose levels in a single session without the insulin hormone being involved (Ambelu & Teferi, 2023). Insulin hormone sensitivity can be raised for up to 48 hours by increasing blood glucose absorption in exercising muscles (Jensen et al., 2023). According to earlier studies, while hypoglycemic, High Intensity Interval Training (HIIT) can boost adrenaline, noradrenaline, glucagon, and overall autonomic nervous system symptoms (Farrell et al., 2020). Nonetheless, following four weeks of high-intensity interval training (HIIT), there was a rise in adrenaline that was higher than in other trials even though it was not statistically significant (Farrell et al., 2020). Other research' results indicate that a 4-week High Intensity Interval Training (HIIT) program can enhance glucagon hormone management by inducing hypoglycemia and symptom responses (Farrell et al., 2020). Blood glucose concentrations will decrease if the pace of glucose synthesis is not able to keep up with the rate of glucose absorption. When the environment shifts and the body experiences hypoglycemia (a drop in insulin levels), the body tries to maintain normal blood glucose levels by raising the amounts of catecholamines and glucagon (Porter et al., 2020).

Results from other research also demonstrate that among young, healthy, and physically active people, low-to-moderate intensity exercise can help prevent the development of atherosclerotic pathology and metabolic problems (Ji et al., 2024). Exercise is one of the best non-pharmacological ways to prevent insulin resistance, and it has also been demonstrated to reduce the chance of developing diabetes mellitus and other metabolic diseases in general (Król et al., 2023). The activation of autophagy and physiological adaption mechanisms have garnered more attention recently as proposed explanations of how exercise affects insulin resistance (Cheng et al., 2022). Frequent exercise and physical activity provide several health advantages, including enhanced cardiovascular fitness, increased muscular mass, and anabolic (Tee et al., 2023). It has been demonstrated that in inactive males with obesity and type 2 diabetes mellitus, High Intensity Interval Training (HIIT), which combines cycling and rowing, successfully improves body composition, VO2max, and insulin sensitivity (Petersen et al., 2022). Therefore Han et al., 2023 evaluates the skeletal muscle's insulin signalling. His study's findings indicate that rat skeletal muscle's sensitivity to the insulin hormone may be raised by exercise.

Regular physical exercise is frequently recommended in conjunction with a balanced diet and a healthy lifestyle to maintain overall health since it has a positive effect on the immune system, musculoskeletal system, and metabolic function (García-Giménez et al., 2024). As a result, non-pharmacological therapy strategies that focus on physical activity and exercise tracking in individuals with diabetes mellitus have been identified as one of the extremely effective and affordable treatment options (Shah et al., 2021). The American Diabetes Association states that physical exercise of a moderate intensity is believed to reduce the acute and long-term effects of diabetes mellitus and enhance blood glucose management (Asfaw & Dagne, 2022). What matters is that the body needs a variety of energy generation methods during vigorous exercise. These mechanisms

include ATP and phosphocreatine, glycogenolysis, aerobic and anaerobic energy, and other vital energy system routes (García-Giménez et al., 2024).

It appears that a number of the insulin signaling cascade's constituents are crucial modulators of mitochondrial organelle activity. Studies on humans and animals have shown that mitochondrial dysfunction might cause disturbances in metabolic processes in individuals with diabetes mellitus (Onikanni et al., 2023). Because of this, there will be an insulin shortage, making type 1 diabetes patients very reliant on exogenous insulin to maintain appropriate glycemic control (Deichmann & Kaltenbach, 2023). Previous studies in obese mice with type 2 diabetes have demonstrated that exercise can enhance glucose metabolism in skeletal muscle by promoting glucose absorption and glycogen breakdown (S. R. Jung et al., 2021). Treatment for type 1 diabetes mellitus has included exercise training, and results have shown small but significant improvements in glucose control (S.-R. Jung et al., 2024).

The following is the process by which physical activity increases the production of glucagon and decreases that of insulin. Hepatic glucose synthesis is triggered by sympathetic activation, which initiates glycogenolysis (Daniela et al., 2022). Blood glucose is the energy source that the body uses when its energy system is activated (Skroce et al., 2024). In order for blood glucose levels to drop during physical activity (Kanaley et al., 2022). Because the insulin hormone's job is to counteract blood glucose increases that are too high, insulin levels will drop when blood glucose levels are low (Han et al., 2023). Therefore, the opposing action of the glucagon hormone is to break down fat or glycogen to be turned into blood glucose if insulin hormone levels fall (Porter et al., 2020). in order for blood glucose levels to stabilize. Blood glucose levels are raised by the secretion of glucagon by pancreatic islet alpha cells, which is facilitated by the gluconeogenesis and glycogenolysis pathways in target organs including the liver (Panzer et al., 2022). The integrated physiological response known as glucose counterregulation, which effectively averts the risk of hypoglycemia, is largely dependent on glucagon (Panzer et al., 2022). The production of the hormone glucagon is also proposed as a function of hypoglycemia in the context of insulin control, which is dependent on glucose (Wendt & Eliasson, 2020). The glucagon hormone is useful for preserving energy balance since it also causes an increase in energy expenditure (Wendt & Eliasson, 2020).

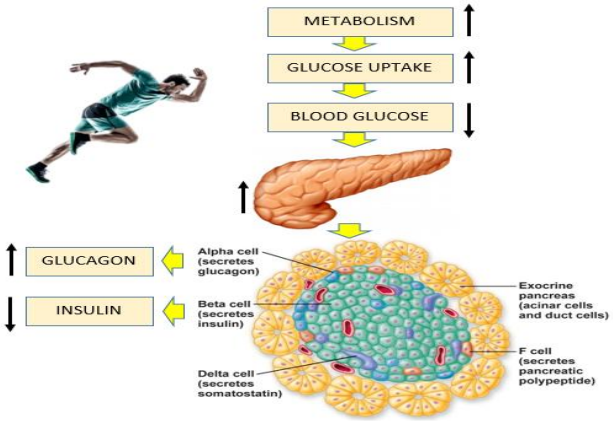

Figure 2. Mechanisms of Physical Exercise Reduces Insulin Hormone Secretion and Increases Glucagon Hormone Secretion

4. CONCLUSION

Exercise has been shown to both increase and decrease the secretion of the glucagon hormone, which is responsible for maintaining the energy system's balance, particularly the balance of blood glucose levels, and to decrease the secretion of the insulin hormone by enhancing the hormone's sensitivity. Exercise is a highly suggested non-pharmacological strategy for improving the function of beta and alpha cells in the pancreatic islets of Langerhans in individuals with diabetes mellitus. It is strongly advised to engage in regular physical activity in an effort to fend off metabolic diseases and preserve overall health.

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