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Systematic Review

Physical Exercise as A Therapy to Prevent Insulin Resistance

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Abstract: Physical exercise is the best therapeutic effort in reducing the adverse effects of diabetes mellitus by reducing the work of the hormone insulin to control blood sugar levels. Research objectives: This study sought to determine how physical activity affects the secretion of insulin hormone levels in humans. Several journal databases such as Web of Science, Pubmed, and Science Direct, were searched for this study. This study took into account several variables, including studies on physical exercise and insulin hormone secretion published in the last five years. Excluded from this systematic review were articles that did not meet the inclusion criteria, for example, non-human samples and non-insulin biomarkers were excluded from this analysis. Using databases from Pubmed, Science Direct, and, Web of Science, a total of 93 publications were found. Ten carefully selected, peer-reviewed articles addressed the need for this sys-temic change. Standard operating procedures for this study were established using Preferred Reporting Systematics and Meta-analysis (PRISMA). Based on the results of this comprehensive study, it is evident that regular and routine physical exercise can reduce insulin in humans. Regular physical exercise has been shown to reduce the secretion of the hormone insulin in humans. The effect of reduced insulin remains to increase the absorption of human blood sugar levels.

Keywords: Physical Exercise, Insulin, Health

1. Introduction

The American Diabetes Association (ADA) defines diabetes mellitus (DM) as a group of metabolic syndrome conditions that are not well managed by either the action or secretion of insulin, or both. In addition, the condition of hyperglycemia also triggers the adverse effects of diabetes mellitus [1]. Diabetes mellitus has a major impact, adverse impact and, negative impact on the lives and long-term health of people, families and communities around the world. An estimated four million people died from the disease globally in 2017, making it one of the top ten leading causes of death in adults [2]. Similar to the prevalence of type 2 diabetes mellitus (T2DM), obesity is becoming more and more common worldwide. By 2045, the prevalence of type 2 diabetes is predicted to rise from 9.3% in 2019 to 10.9% [3]. Impaired glucose tolerance triggered by T2DM causes higher blood sugar to circulate in the blood which results in insulin resistance [4].

When the pancreas secretes too much insulin or insulin is unable to control blood glucose levels, the body is unable to metabolize and regulate blood glucose, leading to diabetes, a chronic and persistent condition [5]. By promoting the uptake of glucose into cells and tissues, as well as the production and storage of glycogen in the muscles and liver, the hormone insulin helps regulate blood glucose levels [6]. Increased blood levels of glucose and triglycerides are the outcome of insulin resistance

(IR), which impacts the ability of muscle cells to take up and hold onto these molecules. IR and poor glucose regulation are risk factors for the emergence of cardiovascular disorders [7]. Insulin therapy may be necessary for patients with diabetes mellitus if their bodies cannot make enough insulin or if their cells are resistant to insulin, which raises blood glucose levels [8]. Type 2 diabetes is frequently linked to obesity and a sedentary lifestyle, and it is typically treated with lifestyle modifications and oral drugs at first [9].

Exercise and physical activity are regarded as essential components in the management and prevention of diabetes mellitus [10]. Exercise is a planned or systematic movement with the particular goal of increasing muscular and/or cardio fitness, whereas physical exercise is often described as any motion of the body above resting circumstances [11]. Exercise is advised by the American College of Sports Medicine (ACSM) and/or the American Diabetes Association (ADA) and physical activity that emphasizes frequency, intensity, and modality to improve glycemic control [12]. The use of exercise as a treatment for metabolic disorders is still neglected, nevertheless. Actually, pharmaceutical treatment or other procedures that are more economically motivated frequently take precedence over physical activity programs [13]. Despite the fact that many healthcare systems now include physical activity counseling, it is still uncommon for activity counseling to be a component of the clinical encounter [14]. It is regrettable that physical activity is not receiving more attention, considering the positive effects of physical exercise therapies on the health of people with metabolic disorders [15].

It is also not yet understood how the mechanism of the positive effects of physical exercise in reducing insulin levels. Does the metabolic system during physical exercise reduce insulin levels and directly use blood sugar levels in the formation of energy. Or there are other factors that can affect the decrease in insulin levels that still need to be understood further. Thus, the function of exercise in lowering insulin levels will be discussed in this systematic review.

2. Materials and methods

Study Design

This study examined and assessed a number of journal databases, such as Pubmed, Web of Science, and Science Direct, as part of a systematic review procedure.

Eligibility criteria

This study was about physical exercise as a therapy to prevent insulin resistance in humans and scientific articles about physical exercise and insulin hormone published in the last five years were the inclusion criteria for this study. Publications not included in our study included papers with non-human samples and did not take markers of insulin levels.

Procedure

Full text, abstracts, and titles of verified and approved publications were added to the Mendeley information database. In the first part of the study, 93 papers were categorized using Pubmed, Web of Science, and Science Direct databases. The second step involved evaluating 90 entries based on their suitability to the research analysis topic and the extent to which their abstracts and titles conformed to the guidelines. The third stage was to process the next 53 entries for further processing. We now conducted the analysis based on whether or not the overall topic was relevant to the problem to be addressed, and excluded articles that were not physical exercise interventions and non-human samples and biomarkers that were not insulin. After careful consideration, ten papers that satisfied the inclusion criteria were chosen and examined for this systematic review. Figure 1 shows the analysis of this study using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) evaluation standard operating procedure. PRISMA flowchart for the process of choosing articles.

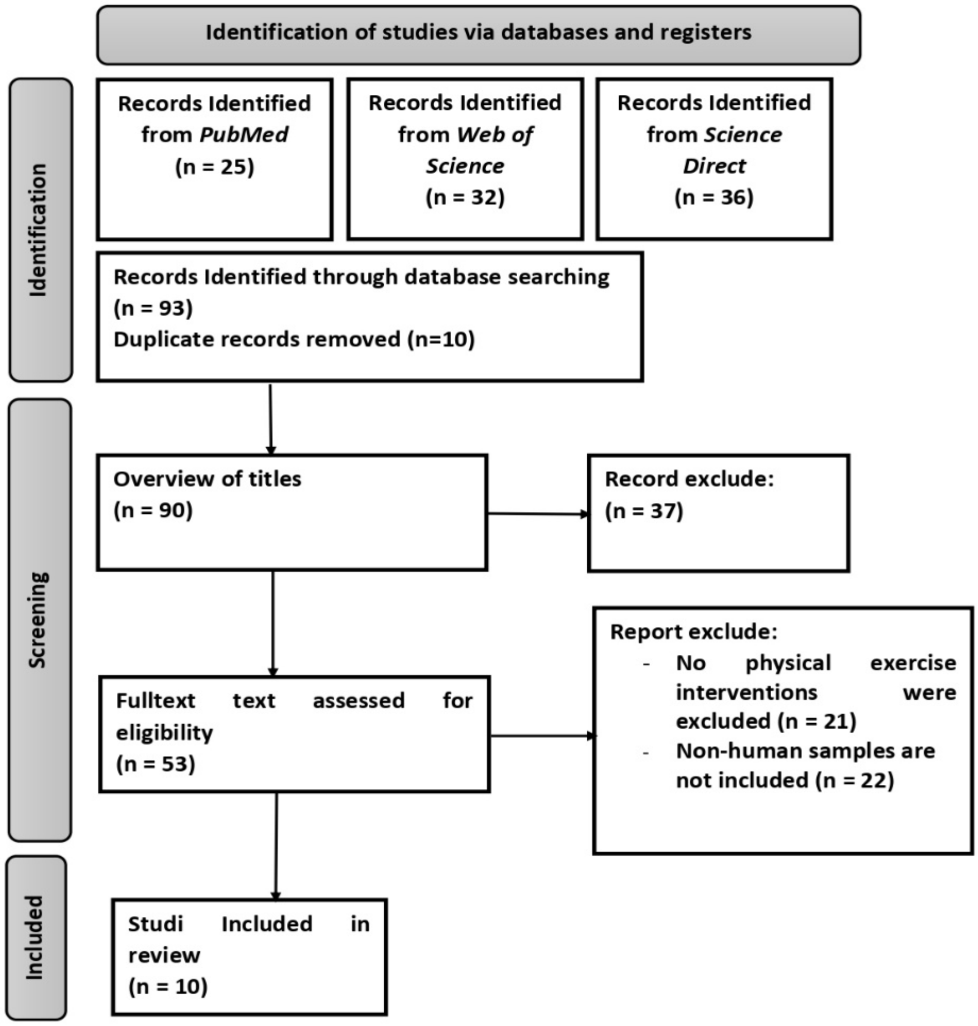

Figure 1. PRISMA flowchart of the article selection process

3. Results

Table 2. Summary of the design and intervention of the studies

Author	Sample Characteristics	Study Design	Intervention	Results
[16] (Ha et al., 2024)	33 elementary school children aged 11-12 years participated in this study and were divided into 2 groups: obese group and non-obese group.	Randomized controlled trial	The study sample underwent a 60-minute physical exercise intervention performed 3x a week for 16 weeks. Exercise consisted of sports games, aerobic training, and resistance training.	There was a significant decrease in insulin hormone levels after the intervention in the obese group $p<0.05$.
[4] (Amaravadi et al., 2024)	This study involved 160 volunteers who were split up into two groups. Group A received the	Randomized controlled trial	The 12-week exercise regimen was followed by the therapy group. Walking and vigorous activities for the upper	The amount of insulin was significantly lower. after

Author	Sample Characteristics	Study Design	Intervention	Results
	physical exercise treatment and group B was the control group.		and lower limbs were part of the workout regimen.	12 weeks of physical exercise intervention p<0.05.
[17] (Beaudry et al., 2022)	24 participants were split into two groups for this study: a male group and a female group.	Randomized controlled trial	The exercise intervention was HIIT with 90% HRmax and MIC with 65% HRmax which was carried out using an ergometer.	There was a significant decrease in insulin levels after physical exercise intervention p<0.05.
[18] (Kao et al., 2020)	42 healthy individuals between the ages of 20 and 64 took part in the study and were split into two groups: one for moderate-intensity activity and one for high-intensity exercise.	Randomized controlled trial	The participants warmed up for 5 minutes to reach their target HR on the treadmill. While LIE participants walked or ran for 60 minutes at 35% heart rate reserve (HRR), HIE participants ran continuously for 20 minutes at 75% HRR.	There was a significant decrease in insulin hormone levels after the HIE exercise intervention. And the peak occurred 120 minutes after exercise. While the LIE group also decreased significantly and the peak occurred 60 minutes after the intervention p<0.05.
[19] (D'alonzo et al., 2021)	This study involved 351 participants who were split into four groups: combination, exercise, weight reduction, and control.	Randomized controlled trial	Participants in the exercise group were required to do 180 minutes of aerobic exercise and two weight training sessions per week. Exercise was carried out for 52 weeks. In the weight loss group, participants took a diet in accordance with the recommendations set by the researcher's guidelines. While the combination group is a diet + exercise group.	Insulin levels significantly dropped in the group that had a combination of diet and exercise after 12 months of intervention p<0.05.
[20] (Malin et al., 2024)	21 people participated in this study to take the pretest and posttest.	Randomized controlled trial	Participants were randomly assigned to 12 sessions of continuous cycle ergometry or job-adapted intervals of 60 minutes/day for 13 days.	There was a significant decrease in insulin hormone levels after the exercise intervention p<0.05.
[21] (Wheeler et al., 2020)	Three groups—the sitting group, the exercise plus sitting group, and the activity + rest group—were formed from the 67 participants in this study.	Randomized controlled trial	The exercise performed was a 30-minute moderate-intensity morning walk at 75% HRmax.	When exercise and rest were combined, the group's insulin levels significantly decreased p<0.05.
[22] (Zhang et al., 2022)	Ten participants completed the pretest and posttest as part of the study.	Randomized controlled trial	The program was moderate intensity resistance training exercising four times a week for 45–60 minutes at 70–75% HRmax for ten weeks.	The levels of the hormone insulin significantly decreased after physical exercise intervention p<0.05.

Author	Sample Characteristics	Study Design	Intervention	Results
[23] (Ragland & Malin., 2024)	Twenty-three women took part in the trial and were split into two groups: one that followed a low-calorie diet and the other that followed a low-calorie diet plus interval training.	Randomized controlled trial	Interval training was performed using a bicycle for 12 sessions. For a total of 60 minutes, each training session was monitored and involved cycling for three minutes at 50% and 90% heart rate peak (HRpeak) intervals.	Insulin hormone levels significantly decreased following a low-calorie diet and interval workout $p<0.05$.
[24] (Petersen et al., 2022)	The study included 48 men in total: 18 lean men, 15 obese men with type 2 diabetes, and 15 obese men.	Randomized controlled trial	Exercise consisted of cycling using an ergometer and rowing performed 3x a week for 8 weeks.	Insulin hormone levels significantly dropped in the group with type 2 diabetes $p<0.05$.

4. Discussion

This research seeks to ascertain how exercise affects the reduction of insulin levels. Based on the results of the study, it is proven that regular physical exercise can reduce insulin levels. The results of previous studies prove that physical exercise with types of sports games, aerobic training, and resistance training in obese participants conducted 60 minutes prove that it is proven to reduce insulin levels after the intervention [16]. This is information that physical exercise in obese people has benefits in reducing insulin levels. So in people with obesity it is highly recommended to do physical exercise regularly. Research from Amaravandi, et all 2024 [4] mentioned that people who had been given physical exercise interventions of walking and active exercise for upper limbs and lower limbs proved to significantly reduce insulin levels after the intervention $p<0.05$.

HIIT type of exercise also had a significant effect on reducing insulin levels [17]. So the type of exercise that is effective in lowering insulin levels in humans remains to be explored further despite previous opinions of HIIT training impacting significant reductions in insulin. A comparison of high-intensity and moderate-intensity exercise was also shown by previous research from Kao, et all 2021 that it turns out that high-intensity exercise has an effect on a significant decrease in insulin at a peak of 120 minutes after exercise, while those with low intensity exercise peak at 60 minutes after exercise. It can be concluded that high intensity exercise has a longer insulin reduction time than low intensity exercise [18]. We have limitations and it is not yet known exactly which effectiveness between HIIT and MICT on improving insulin sensitivity. However, in previous studies we have shown that the HIIT exercise protocol in groups with diabetes mellitus significantly improved insulin sensitivity. [25]. So that with this evidence it can be a therapeutic recommendation for people with diabetes mellitus, especially in improving insulin sensitivity function.

The results of another study provide new evidence that the combination of a low-calorie diet combined with exercise has a significant impact on insulin reduction after 12 months of intervention [19]. Research results Malin et all., 2024 also reinforced that physical exercise was shown to significantly reduce insulin levels after the intervention [20]. In addition, morning walking exercise with moderate intensity at 75% HRrmax also had a significant effect on insulin reduction after the intervention [21]. Exercise with moderate intensity is highly recommended in therapy for insulin resistance. The results of the study show that moderate-intensity resistance training performed for 45-60 minutes 4x a week for 10 weeks significantly reduces insulin levels [22]. So it can indeed be said that physical exercise is the best therapy in preventing insulin resistance.

However, the mechanism by which physical exercise reduces insulin levels in humans remains to be further explored. The World Health Organization defines that doing moderate-intensity physical activity of less than 150 minutes per week or vigorous-intensity activity of less than 75 minutes per week is recommended [26]. Various metabolic syndrome diseases such as hypertension, dyslipidemia, obesity, insulin resistance and type 2 diabetes mellitus are closely related to a sedentary lifestyle which if left unchecked will worsen one's health condition [27]. Exercise increases 17-fold the permeability of muscle membrane to blood glucose [28]. Increased insulin sensitivity also occurs during exercise, skeletal muscle also plays a role in 35-fold membrane permeability to glucose [28]. So that by exercising, the absorption of glucose increases significantly to meet the energy needs of skeletal muscles in order to remain able to carry out their functions properly.

Increased blood flow and glucose delivery, increased sarcolemma transport mediated by the protein GLUT4 glucose transporters, and increased glucose disposal the initial step of which is glucose phosphorylation catalyzed by hexokinase all contribute to the facilitated diffusion and increased absorption of skeletal muscle glucose uptake during exercise [29]. GLUT4 translocation to the t-tubules and plasma membrane during exercise [30] is essential for promoting the absorption of glucose by skeletal muscle and successfully removing glucose transport as a limiting factor [29]. Most, if not all, of the increase in skeletal muscle glucose transport during exercise is thought to be caused by GLUT4 translocation; yet, the potential of increased intrinsic activity of GLUT4 transporters is still an open question [28]. Thus, further review of experimental studies on this subject should be conducted. In contrast, exercise and muscle contraction had no effect on the phosphorylation of insulin receptors and IRS-1 or on the activity of PI3-K [31], and specific shutdown of insulin receptors in muscle does not interfere with glucose transport stimulated by contraction [31]. Clearly, these data suggest that the initial signals leading to GLUT4 translocation by insulin and exercise in skeletal muscle are clearly different. Previous research results from Ayubi et all., 2024 proved that physical exercise increases the GLUT4 translocation mechanism so that this increases glucose uptake during physical exercise [32]. Skeletal muscle's use of glucose as the preferred exercise substrate is also very closely supported by increased expression of glucose transporters [33]. Various types of exercise have a significant impact on increasing GLUT4 translocation. In individuals with diabetes mellitus, elevated GLUT4 translocation also regulates blood sugar levels [34]. Since skeletal muscle makes approximately 40% of the body's mass, the regulation of skeletal muscle glucose metabolism greatly affects the blood sugar balance of the body [35]. Exercise can effectively increase the absorption of glucose in skeletal muscle [36]. By enhancing blood glucose uptake, GLUT4 offers a biological signaling pathway that is activated by insulin to reduce blood glucose levels [37].

The translocation of GLUT4 proves that there is an increase in blood glucose uptake. So that the low blood glucose level during physical exercise also has an impact on lowering insulin levels, which is a therapeutic effort to prevent insulin resistance and efficient use of insulin. In addition to physical exercise, reducing daily consumption or restricting calories in combination with interval training significantly decreased insulin levels [23]. For physiotherapists, the recommended exercise as therapy is the HIIT type of exercise. It has been proven from previous studies that this exercise is effective and significant in improving insulin sensitivity in patients with diabetes mellitus. The duration of exercise in accordance with WHO recommendations is 150 minutes per week. However, there must be a doctor's examination first to find out the patient's condition. So that it can determine an effective program in therapy. In addition, to achieve training with HIIT, exercise adaptation is needed and in principle physiologically this occurs gradually and there should be no coercion. So the increase in exercise intensity is carried out gradually to the desired point and must still be supervised by a doctor regarding the patient's health condition. In patients with diabetes mellitus, exercise performed 3x a week for 8 weeks also significantly impacts insulin reduction after the intervention [24]. So that this can prove the real effect of therapy with physical exercise to control blood sugar through insulin. The limitation in this research analysis is only reviewing how physical exercise in lowering the hormone insulin. However, it is still unclear what exercises are effective for lowering insulin and as a suitable therapy in particular for people with diabetes mellitus, therefore further research is recommended to be carried out.

5. Conclusions

The results of this study prove that physical exercise has been proven to increase insulin sensitivity. Increased GLUT4 translocation during physical exercise helps increase glucose absorption and increase energy expenditure. Thus, insulin decreases because blood glucose levels also decrease which is triggered by physical exercise. Physical exercise is the best therapeutic effort as glycemic control in humans.

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