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A Systematic Review of the Effectiveness of Resistance Training in Lowering Blood Glucose Levels in Patients with Type II Diabetes Mellitus

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ABSTRACT

Latihan beban adalah bentuk latihan fisik yang sering direkomendasikan untuk penderita diabetes melitus. Tujuan dari penelitian ini adalah untuk menginvestigasi pengaruh latihan beban terhadap penurunan kadar glukosa darah pada pasien diabetes melitus tipe 2. Sebuah tinjauan literatur sistematis dilakukan dengan menelusuri database PubMed dan Google Scholar menggunakan kata kunci yang telah ditentukan. Setelah penerapan kriteria inklusi dan eksklusi, lima artikel yang relevan dipilih untuk dianalisis. Tinjauan ini mengungkapkan bukti signifikan yang mendukung efektivitas latihan beban dalam menurunkan konsentrasi glukosa darah di antara populasi pasien ini. Temuan ini menyoroti potensi latihan beban sebagai intervensi non-farmakologis yang layak untuk mengelola diabetes tipe 2; namun, penelitian lebih lanjut diperlukan untuk menilai secara komprehensif dampak jangka panjangnya terhadap regulasi glikemik.

Resistance training is a frequently recommended form of physical exercise for individuals with diabetes mellitus. The objective of this study was to investigate the effect of resistance training on the reduction of blood glucose levels in patients with type 2 diabetes mellitus. A systematic literature review was conducted by searching the PubMed and Google Scholar databases using predefined keywords. Following the application of inclusion and exclusion criteria, five relevant articles were selected for analysis. The review revealed significant evidence supporting the effectiveness of resistance training in lowering blood glucose concentrations among this patient population. These findings highlight the potential of resistance training as a viable non-pharmacological intervention for managing type 2 diabetes; however, further research is warranted to comprehensively assess its long-term impact on glycemic regulation.

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Introduction

Diabetes mellitus is a metabolic disorder characterized by elevated blood glucose levels (hyperglycemia) resulting from impaired insulin production or function (Yuantari, 2022). This condition arises from defects in the mechanisms of insulin secretion or in the cellular response to insulin. Global health projections from the World Health Organization (WHO) identify diabetes as a critical global health challenge (Bull et al., 2020).

In Indonesia, demographic trends indicate an alarming trajectory. Projections estimate that the population of individuals with diabetes will increase from approximately 8.4 million to nearly 21.3 million by 2030, potentially more than doubling within two decades. Data from the 2018 National Health Research (Riskesdas) corroborate this trend, documenting an increase in prevalence from 1.5% in 2013 to 2.0% in 2018, which underscores the urgent need for comprehensive intervention strategies (Ministry of Health of the Republic of Indonesia, 2019).

The management of diabetes involves a multifaceted approach that includes educational programs, nutritional counseling, physical activity, and pharmacological interventions (Marbun, 2022). Among the recommended physical exercises, resistance training is a prominent component, alongside aerobic and flexibility-balance exercises (Suryawan, 2022).

Resistance training represents a structured and controlled physical intervention designed to activate muscular mechanisms, thereby facilitating glucose uptake (Novita Fajriyah & Ida Trisnawati, 2020) and reducing insulin dependence (Rudi et al., 2023). This form of exercise activates a series of complex processes that fundamentally modify glucose metabolism through several key mechanisms. Resistance exercise promotes the translocation of the glucose transporter protein GLUT4 to the muscle cell membrane, which significantly enhances insulin-independent glucose uptake. Research by Ma et al. (2024) revealed that muscle contraction can induce glucose transport via pathways distinct from insulin signaling.

Furthermore, the activation of metabolism-related genes through resistance training results in the upregulation of proteins that enhance insulin sensitivity; thus, muscle exercise can epigenetically modify the expression of genes involved in glucose metabolism. Resistance training also reduces systemic inflammation by lowering inflammatory markers such as TNF-α and IL-6, which contribute to insulin resistance. A study by Chen et al. (2024) demonstrated a significant correlation between reduced inflammation and improved insulin sensitivity. Additionally, it enhances mitochondrial efficiency, optimizing fatty acid oxidation and glucose utilization. Zheng et al. (2024) identified increased mitochondrial biogenesis as a key mechanism in the improvement of energy metabolism. Contemporary research (Li, 2024; Rezaeeshirazi, 2022) indicates the superiority of resistance training over traditional aerobic protocols in the management of glycemic indicators.

Based on the aforementioned research gap analysis, the objective of this study is to determine the effect of resistance training on lowering blood glucose levels in patients with type 2 diabetes mellitus.

Methods

This study employed a systematic literature review methodology, which involved the comprehensive collection of data from scholarly sources, a critical evaluation of existing research, and an in-depth analysis of academic publications relevant to the research question (Cahyono et al., 2019). The entire review process was structured in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

A systematic literature search was conducted using the Google Scholar and PubMed databases. The search strategy utilized a combination of specific keywords, including: "resistance training," "resistance exercise," "blood glucose," "gula darah," "type 2 diabetes," and "diabetes tipe 2."

The selection of articles was guided by predefined inclusion and exclusion criteria. The inclusion criteria were as follows: (1) articles with themes relevant to the research question; (2) publications in either English or Indonesian; (3) studies published within the last five years, specifically from 2019 to 2024; (4) open-access manuscripts; and (5) studies focusing on a population of patients with type 2 diabetes mellitus.

Conversely, studies were excluded if they met any of the following criteria: (1) publication prior to 2019; (2) language of publication other than English or Indonesian; (3) articles that were not open-access; (4) publications that were not primary research or journal articles (e.g., editorials, non-systematic reviews); or (5) duplicate publications and articles deemed irrelevant to the topic.

The guiding research question for this review was: "What is the effect of resistance training on lowering blood glucose levels in patients with type 2 diabetes mellitus?" To structure the review and ensure a focused analysis, the Population, Intervention, Comparator, and Outcome (PICO) framework was employed: Population (P): Patients with type 2 diabetes mellitus, Intervention (I): Resistance training, Comparator (C): A control group (e.g., no intervention or alternative intervention), Outcome (O): Changes in blood glucose values.

Furthermore, the Joanna Briggs Institute (JBI) critical appraisal checklist was utilized to assess the methodological quality of the selected studies.

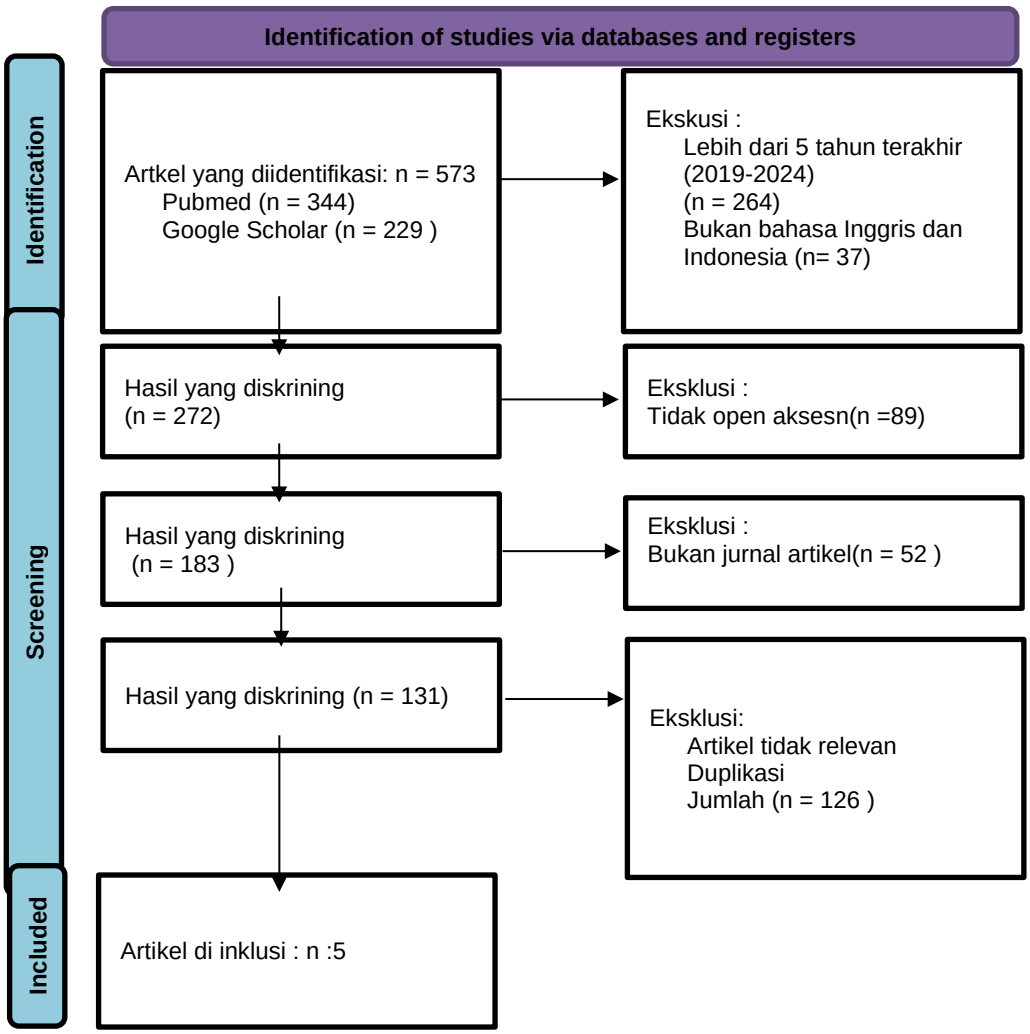

Figure 1. PRISMA flow diagram illustrating the study selection process.

Results

The literature search yielded five articles that fulfilled the inclusion criteria. The characteristics of these studies are summarized in Table 1 below.

Table 1. The following chapter provides a Literature Review, which synthesizes the key findings from previous research

No	Title, Researcher/Auhtor, Year of Publication	Methods	Result
1.	*The effect of periodic resistance training on obese patients with type 2diabetic nephropathy* Li et al 2024	This randomized experimental study involved 60 patients diagnosed with type 2 diabetes mellitus, obesity, and neuropathy. Participants were randomly allocated to one of two intervention groups: an aerobic training group or a resistance training group. The intervention period for both groups was 12 weeks; it is noted that the study design did not include a non-intervention control group. All statistical analyses were performed using SPSS software (Version 22.0). T-tests were used to conduct between-group and within-group comparisons of the relevant outcome variables.	Following the intervention, significant improvements were observed in both groups. Specifically, levels of low-density lipoprotein (LDL) cholesterol, fasting blood glucose (FBG), fasting insulin (FINS), glycated hemoglobin (HbA1c), and the urinary albumin-to-creatinine ratio (uACR) decreased, while the estimated glomerular filtration rate (eGFR) increased (all $p < .05$). The observed reductions in these key metabolic and renal markers underscore the potential of resistance training for managing the metabolic profile of patients with diabetes.
2.	*Aerobic versus Resistance Training : Leptin and Metabolic Parameter Improvement in Type 2 Diabetes Obese Men* Rezaeeshirazi, Reza 2019	This study was designed as a randomized controlled trial involving 45 obese male patients with type 2 diabetes, aged 17–25 years. Participants were randomly allocated to one of three groups for a two-month intervention period: an Aerobic Training (AT) group, a Resistance Training (RT) group, or a non-intervention Control (CO) group. The intervention groups (AT and RT) engaged in four training sessions per week. For the statistical analysis, a factorial analysis of variance (ANOVA) was employed, followed by the Bonferroni post-hoc	The factorial analysis of variance (ANOVA), followed by the Bonferroni post-hoc test, revealed significant reductions in the levels of leptin ($p = .043$), fasting blood glucose ($p = .023$), and insulin ($p = .001$). These findings suggest that aerobic exercise holds superior potential for the metabolic regulation of type 2 diabetes, operating primarily through the modulation of leptin and the improvement of insulin resistance.

		test for multiple comparisons.	
3.	Pengaruh *Resistance Exercise* Terhadap Nilai Ankle Brachial Index Dan Penurunan Kadar Glukosa Darah Pada Pasien Diabetes Melitus Tipe 2 Di Wilayah Kerja PuskesmasPoncokusumo Malang Ervanti et al.2023	This study employed a quasi-experimental design with a pretest-posttest control group. A total of 68 participants were allocated to one of two groups: an experimental group that received a resistance exercise intervention, and a control group. Data were collected via observation and subsequently analyzed using a paired t-test to assess the significance of differences between pre-intervention and post-intervention values within each group.	The intervention group demonstrated a greater mean reduction in blood glucose levels (56.353) compared to the control group (45.559). This finding supports the alternative hypothesis (H1), indicating that the resistance training intervention had a significant effect on both ankle-brachial index values and blood glucose reduction. This outcome is attributed to the physiological mechanism whereby resistance exercise enhances glucose utilization by the muscles, which in turn contributes to the observed decrease in blood glucose levels.
4.	Effects of Acute resistance exercise with and without Whole-Body Electromyostimulation and endurance Exercise on the postprandial Glucose regulation in Patients with Type 2 Diabetes mellitus : A Randomized Crossover Study Holzer et al.2021	This study utilized a randomized crossover design involving six participants with type 2 diabetes. Each participant completed three distinct exercise interventions: (1) resistance training with whole-body electromyostimulation (WB-EMS); (2) resistance training without WB-EMS; and (3) cycling endurance training. To analyze the data, the non-parametric Friedman test was employed to compare differences across the three conditions. Subsequently, the Dunn-Bonferroni post-hoc test was performed to identify which specific pairs of interventions differed significantly from one another.	Postprandial glucose elevations were attenuated in all experimental conditions. Notably, the endurance training intervention demonstrated a superior trend in reducing glucose levels during the recovery phase. This may be attributed to the continuous nature of the activity, which is hypothesized to be more effective than the intermittent format of resistance training. The overall improvement in glucose uptake across the interventions is likely mediated by established physiological mechanisms, including the translocation of GLUT4 transporters and enhanced insulin sensitivity.
5.	Effect of Blood flow-restrictive resistance training on metabolic disorder and body composition in order adults with type 2 diabetes : a randomized controlled study Ma et al.2024	This study was a randomized controlled trial (RCT) involving 98 older adults with type 2 diabetes mellitus. Participants were randomly allocated to one of three groups: (1) a blood flow restriction resistance training group; (2) a conventional resistance training (RT) group; or (3) a non-	Participants in both exercise groups demonstrated significant improvements across a range of outcomes when compared to the control group and their own baseline measurements (all $p < .05$). These improvements included Fasting Plasma Glucose (FPG), glycated hemoglobin (HbA1c), lipid profiles, diastolic blood pressure, body composition, and muscle performance. These findings indicate that resistance training with blood flow restriction, in particular, is an effective strategy for

	intervention control group. Over a six-month period, participants in both exercise groups engaged in supervised training sessions, each lasting 50 minutes, conducted three times per week. Differences between the groups were assessed using a one-way analysis of variance (ANOVA).	enhancing glycemic control and overall cardiometabolic health in older adults with type 2 diabetes mellitus.

Discussion

The results of the literature review indicate that resistance training can lower blood glucose and/or glycated hemoglobin (HbA1c) levels. A study by Li et al. (2024) involving 60 obese patients with type 2 diabetic nephropathy found that a 12-week intervention led to a reduction in fasting blood glucose and HbA1c levels. The reduction in these markers was significantly more pronounced in the resistance training group compared to the aerobic training group. Similarly, research by Rezaeeshirazi et al. (2022) on 45 obese patients with type 2 diabetes demonstrated a significant decrease in fasting blood sugar (FBS) after an 8-week intervention in both the resistance and aerobic training groups ($p = .023$). A study by Ervanti et al. (2023) also reported a reduction in blood glucose levels in 64 patients with type 2 diabetes. Following the intervention, the mean reduction in blood glucose was greater in the resistance training group (56.353) compared to the control group (45.559).

Furthermore, in a study by Holzer et al. (2021), an intervention was conducted on six participants with type 2 diabetes, consisting of resistance training with whole-body electromyostimulation (WB-EMS), resistance exercise without electromyostimulation (RES), and cycling endurance training (END), all performed after breakfast. The results indicated that postprandial blood glucose elevations were reduced in all intervention scenarios. Additionally, a study by Ma et al. (2024) involved 98 participants divided into three groups: a blood flow-restrictive resistance exercise group, a moderate-intensity resistance training group, and a control group. After a 6-month intervention, values for Fasting Plasma Glucose (FPG), HbA1c, blood lipids, diastolic blood pressure, body composition, and muscle performance in the two exercise groups showed significant improvement compared to both the control group and baseline measurements ($p < 0.05$).

This systematic review of the five selected articles consistently demonstrates the potential of resistance training to lower blood glucose levels. The studies, conducted across diverse populations, confirm statistically significant improvements in glycemic control.

These findings align with clinical guidelines from the World Health Organization (WHO) (Bull et al., 2020) and the American Diabetes Association (ADA) (Care & Suppl, 2020), both of which recommend a combination of aerobic and resistance exercise as part of diabetes management. The WHO recommends at least 150 minutes of moderate-intensity physical activity per week, incorporating resistance training two to three times per week to enhance metabolic health.

The implementation of resistance training in clinical practice presents a significant opportunity to improve glycemic control in patients with diabetes. This form of exercise is not only effective in lowering blood glucose levels but also contributes to increased muscle mass and improved cardiovascular health. However, several challenges must be addressed, including time constraints, limited access to adequate exercise facilities, and a lack of understanding regarding proper exercise techniques. Therefore, it is crucial for healthcare professionals to provide sufficient education on the benefits and methods of resistance training to ensure patients can implement such programs effectively. Moreover, social support from family and the community is vital for encouraging and sustaining patient participation in these exercise programs.

Limitation

The primary limitations of this review include the limited number of available articles, particularly studies conducted within the Indonesian context. Furthermore, the included studies exhibited considerable heterogeneity in their research designs, participant demographics, and intervention protocols. This variability may restrict the direct comparability of the findings and, consequently, affects the overall generalizability of the results. These factors, coupled with the potential for selection bias within the primary studies, should be considered when interpreting the conclusions of this review.

For future research, it is recommended that studies utilize larger, more representative samples. Moreover, the adoption of standardized resistance training protocols and more consistent research methodologies is crucial to strengthen the evidence base and allow for more robust comparisons and meta-analyses.

Conclusions

This literature review provides compelling evidence supporting resistance training as an effective non-pharmacological strategy for glycemic control.

To build upon these findings, future research should focus on optimizing training protocols by investigating the long-term effects of varying frequencies, intensities, and durations. Designing well-structured resistance training programs with appropriate parameters is essential. Furthermore, future studies should aim to involve more diverse populations, encompassing various age groups and fitness levels, to enhance the generalizability of the findings.

A critical next step is the development of practical, accessible guidelines for both healthcare professionals and patients. Such guidance is essential to facilitate the broader and more effective implementation of resistance training in day-to-day diabetes management. To this end, collaboration between researchers, healthcare practitioners, and patients is highly recommended to create training programs that are not only evidence-based but also relevant and adapted to local contexts.

Through an integrated, evidence-based approach, it is anticipated that resistance training can become an integral component of effective and sustainable diabetes management strategies.

Conflict of Interest

The authors declare that they have no known competing financial or commercial interests that could have appeared to influence the work reported in this paper. All parties involved were committed to maintaining the integrity of the research.

Credit Author Statement

Diah Ratri Larasati : Conceptualization, Investigation, Methodology . **Suriadi :** Writing-review & editing, Investigation, Writing-original draft, Data curation.

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