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# The Role Physical Activity in the Prevention and Control of Diabetes Mellitus – A Narrative Review

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**Abstract**

Diabetes mellitus is one of the most prevalent chronic non-communicable diseases worldwide and constitutes a major public health challenge due to its growing incidence, high morbidity and mortality, and substantial socioeconomic burden. Insufficient physical activity has been identified as a key modifiable risk factor contributing to the development and progression of diabetes, particularly type 2 diabetes mellitus, but also influencing metabolic control and complication risk in type 1 diabetes mellitus. The present narrative review summarizes current evidence regarding the role of physical activity in the prevention and control of diabetes mellitus. A comprehensive analysis of peer-reviewed original studies, systematic reviews, and clinical guidelines was conducted. The available evidence demonstrates that regular physical activity significantly reduces the risk of developing type 2 diabetes, improves glycemic control and insulin sensitivity in individuals with established diabetes, and exerts beneficial effects on cardiovascular fitness, body composition, inflammatory status, and oxidative stress. Furthermore, physical activity has been shown to attenuate the progression of both microvascular and macrovascular complications. These findings support the inclusion of structured physical activity as a fundamental component of diabetes prevention strategies and routine clinical management.

**Background:**Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion, impaired insulin action, or a combination of both. The global prevalence of diabetes has increased markedly over recent decades, driven by population aging, urbanization, obesity, sedentary lifestyles, and unfavorable dietary patterns. Type 2 diabetes mellitus accounts for more than 90% of all cases and is strongly associated with modifiable lifestyle factors, whereas type 1 diabetes mellitus is primarily autoimmune in origin but similarly associated with elevated cardiovascular risk and reduced life expectancy.

Physical inactivity has emerged as an independent risk factor for insulin resistance, impaired glucose tolerance, cardiovascular disease, and premature mortality. Skeletal muscle, the primary site of insulin-mediated glucose uptake, plays a central role in glucose homeostasis and represents a key target for exercise-induced metabolic adaptations. Regular physical activity improves glucose uptake through both insulin-dependent and insulin-independent mechanisms and induces favorable changes in mitochondrial function, lipid metabolism, inflammatory signaling, and antioxidant defense systems. Consequently, increasing attention has been

directed toward physical activity as a cost-effective and scalable intervention for diabetes prevention and long-term disease control.

**Aim:**The aim of this review was to evaluate the role of physical activity in the prevention of diabetes mellitus and in the metabolic control and complication management of individuals with established type 1 and type 2 diabetes mellitus.

**Material and Methods:**This narrative review was based on an analysis of peer-reviewed scientific literature, including original research articles, randomized controlled trials, observational studies, systematic reviews, and expert consensus statements. The included publications focused on epidemiology, pathophysiological mechanisms, clinical outcomes, and exercise prescription related to physical activity in diabetes prevention and management.

**Results:**The reviewed evidence consistently demonstrates that regular physical activity is associated with a substantial reduction in the risk of developing type 2 diabetes mellitus. In individuals with established diabetes, physical activity improves glycemic control, insulin sensitivity, lipid profile, blood pressure, and cardiorespiratory fitness. Both aerobic and resistance exercise modalities provide metabolic benefits, with combined training programs yielding the most pronounced effects. Additionally, regular physical activity reduces markers of systemic inflammation and oxidative stress and attenuates the progression of diabetes-related microvascular and macrovascular complications.

**Conclusions:**Physical activity represents a fundamental, evidence-based component of diabetes prevention and management. Its regular incorporation into lifestyle interventions and clinical care is essential for improving metabolic control, reducing complication risk, and enhancing long-term health outcomes in individuals at risk of or living with diabetes mellitus.

**Key words:**physical activity; exercise; diabetes mellitus; prevention; metabolic control.

## 1. Introduction

Diabetes mellitus is a chronic metabolic disease that poses one of the greatest challenges to modern healthcare systems. The condition is characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both, and is associated with a wide range of acute and chronic complications. Diabetes substantially increases the risk of cardiovascular disease, chronic kidney disease, neuropathy, retinopathy, musculoskeletal dysfunction, and premature mortality. In addition to its clinical consequences, diabetes imposes a considerable economic burden related to direct healthcare costs and loss of productivity.

Type 2 diabetes mellitus (T2DM) accounts for the majority of diabetes cases worldwide and is strongly associated with modifiable lifestyle factors. Excess caloric intake, physical inactivity, and obesity contribute to the development of insulin resistance and progressive β-cell dysfunction, which together lead to impaired glucose homeostasis. In contrast, type 1 diabetes mellitus (T1DM) results from autoimmune destruction of pancreatic β-cells and absolute insulin deficiency; however, individuals with T1DM are also exposed to increased cardiometabolic risk and benefit from lifestyle interventions aimed at improving metabolic control and reducing long-term complications.

Physical inactivity has been recognized as an independent risk factor for insulin resistance, impaired glucose tolerance, cardiovascular disease, and all-cause mortality. Modern societies are characterized by prolonged sedentary behavior and reduced occupational and recreational physical activity, which together promote positive energy balance and ectopic lipid accumulation. Skeletal muscle, the primary site of insulin-mediated glucose disposal, becomes less responsive to insulin in physically inactive individuals, contributing to systemic metabolic dysfunction.

Regular physical activity induces a wide range of physiological adaptations that are particularly relevant to diabetes prevention and management. Muscle contractions stimulate glucose uptake via insulin-independent pathways, primarily through the translocation of glucose transporter type 4 (GLUT-4) to the muscle cell membrane. Exercise training enhances mitochondrial density and function, improves lipid oxidation, reduces visceral adiposity, and attenuates chronic low-grade inflammation. These adaptations counteract key mechanisms underlying insulin resistance and β-cell stress.

In individuals with established diabetes, physical activity improves glycemic control, reduces glycemic variability, lowers cardiovascular risk, and contributes to the preservation of functional capacity and quality of life. Nevertheless, despite strong scientific evidence and clear international recommendations, physical activity remains underutilized as a therapeutic tool in routine diabetes care. Barriers include limited time during clinical visits, lack of structured exercise programs, concerns about hypoglycemia, and insufficient education of healthcare professionals regarding exercise prescription.

Given the growing global burden of diabetes and the limitations of pharmacological therapy alone, a comprehensive evaluation of the role of physical activity in diabetes prevention and control is warranted. Understanding the mechanisms, clinical effects, and practical implementation of physical activity interventions is essential for improving long-term outcomes in individuals at risk of or living with diabetes mellitus.

## 2.Research materials and methods

This narrative review was conducted using peer-reviewed scientific literature provided by the author. The analyzed publications included original research articles, randomized controlled trials, observational cohort studies, systematic reviews, and expert consensus documents focusing on physical activity in the context of diabetes prevention and management.

The reviewed studies encompassed a broad range of populations, including individuals with normal glucose tolerance, prediabetes, type 1 diabetes mellitus, and type 2 diabetes mellitus. Both adult and older populations were considered, as well as studies addressing individuals with obesity and diabetes-related complications. The analysis included investigations conducted in clinical, community-based, and population-level settings.

The reviewed literature addressed multiple domains relevant to the objectives of this article. Epidemiological studies examining associations between physical activity levels, cardiorespiratory fitness, and diabetes incidence were analyzed to assess the preventive potential of physical activity. Interventional studies evaluating structured exercise programs were reviewed to determine their effects on glycemic control, insulin sensitivity, body composition, lipid profile, blood pressure, and cardiovascular fitness.

Mechanistic studies investigating the physiological and molecular effects of exercise were included to elucidate pathways through which physical activity influences glucose metabolism and insulin action. Particular attention was paid to skeletal muscle adaptations, mitochondrial function, inflammatory signaling, oxidative stress, and autonomic nervous system regulation.

Studies examining the impact of physical activity on diabetes-related microvascular and macrovascular complications were also considered.

Exercise interventions were categorized according to modality (aerobic, resistance, combined, and high-intensity interval training), intensity, frequency, and duration. Where available, dose–response relationships between physical activity volume and metabolic outcomes were analyzed. Studies addressing safety considerations, including hypoglycemia risk in individuals with type 1 diabetes, were also reviewed.

Given the narrative nature of this review, no formal meta-analytic procedures were applied. Instead, findings were synthesized qualitatively to provide a comprehensive overview of current evidence and to identify consistent patterns across different study designs and populations. The emphasis was placed on clinically relevant outcomes and practical implications for diabetes prevention and management.

## 3. Research results

### 3.1. Physical Activity and the Prevention of Type 2 Diabetes Mellitus

The reviewed epidemiological and interventional studies provide strong and consistent evidence that regular physical activity significantly reduces the risk of developing type 2 diabetes mellitus. Large prospective cohort studies demonstrate an inverse association between physical activity levels and diabetes incidence, with risk reductions ranging from approximately 25% to over 50% in individuals engaging in moderate to high levels of physical activity compared with sedentary populations. Importantly, these associations remain significant after adjustment for body mass index, age, sex, and other lifestyle factors, indicating that physical activity exerts protective effects independent of weight loss.

Interventional studies conducted in individuals with impaired fasting glucose or impaired glucose tolerance further confirm the preventive role of physical activity. Structured lifestyle programs incorporating regular aerobic exercise, resistance training, or a combination of both have been shown to delay or prevent progression to overt type 2 diabetes. The magnitude of risk reduction observed in these trials is comparable to, and in some cases exceeds, that achieved with pharmacological interventions. These findings underscore the clinical relevance of physical activity as a primary prevention strategy.

Evidence also suggests a dose–response relationship between physical activity and diabetes risk. Higher volumes of physical activity and greater cardiorespiratory fitness are associated with

progressively lower diabetes incidence. Even modest increases in daily physical activity, such as brisk walking, appear sufficient to confer meaningful metabolic benefits, highlighting the feasibility of physical activity interventions at the population level.

### 3.2. Effects of Physical Activity on Glycemic Control in Type 2 Diabetes

In individuals with established type 2 diabetes mellitus, physical activity consistently improves glycemic control. Randomized controlled trials and meta-analyses report reductions in glycated hemoglobin (HbA1c) typically ranging from 0.4% to 1.0%, depending on exercise modality, intensity, and intervention duration. These reductions are clinically meaningful and comparable to those achieved with some glucose-lowering medications.

Both aerobic and resistance exercise independently improve glycemic control; however, combined training programs generally produce superior outcomes. Aerobic exercise improves insulin sensitivity and enhances glucose uptake during and after exercise, whereas resistance training increases skeletal muscle mass and improves basal metabolic rate, thereby enhancing long-term glucose disposal. Combined interventions exploit the complementary mechanisms of these modalities and are therefore particularly effective.

Notably, improvements in glycemic control are often observed even in the absence of significant weight loss. This finding emphasizes that exercise-induced metabolic adaptations, such as increased insulin sensitivity and improved mitochondrial function, play a central role in glucose regulation independent of changes in body mass.

### 3.3. Impact on Insulin Sensitivity and Skeletal Muscle Function

Skeletal muscle is the primary site of insulin-mediated glucose uptake and a key determinant of whole-body insulin sensitivity. The reviewed studies demonstrate that regular physical activity enhances insulin sensitivity through multiple mechanisms, including increased GLUT-4 expression, improved insulin signaling, and enhanced mitochondrial oxidative capacity.

Resistance training has been shown to counteract diabetes-related skeletal muscle atrophy and improve muscle strength and functional capacity. These adaptations are particularly important in older adults with diabetes, in whom sarcopenia and reduced physical function contribute to frailty, disability, and reduced quality of life.

Exercise-induced improvements in muscle function also have important implications for long-term metabolic health, as increased muscle mass and strength are associated with improved glucose tolerance and reduced insulin resistance.

### 3.4. Effects on Body Composition, Lipid Profile, and Blood Pressure

Physical activity exerts favorable effects on body composition by reducing visceral adiposity and preserving or increasing lean muscle mass. Visceral fat reduction is particularly relevant in type 2 diabetes, as excess abdominal adiposity is strongly associated with insulin resistance, dyslipidemia, and cardiovascular risk.

Across the reviewed studies, regular physical activity was associated with reductions in triglyceride levels, modest increases in high-density lipoprotein cholesterol, and improvements in low-density lipoprotein particle profile. Exercise interventions also consistently lowered systolic and diastolic blood pressure, contributing to overall cardiovascular risk reduction.

These cardiometabolic benefits highlight the role of physical activity as a multifaceted intervention targeting multiple components of the metabolic syndrome commonly present in individuals with diabetes.

### 3.5. Physical Activity in Type 1 Diabetes Mellitus

In individuals with type 1 diabetes mellitus, physical activity provides numerous health benefits, although its effects on glycemic control are more variable than in type 2 diabetes. The reviewed studies indicate that regular physical activity improves insulin sensitivity, cardiorespiratory fitness, body composition, and quality of life in this population.

While reductions in HbA1c are not consistently observed, exercise is associated with reduced glycemic variability and lower daily insulin requirements. These effects are clinically relevant, as glycemic variability has been linked to oxidative stress and the development of diabetes-related complications.

Different exercise modalities elicit distinct glycemic responses in individuals with type 1 diabetes. Prolonged moderate-intensity aerobic exercise is more frequently associated with exercise-induced hypoglycemia, whereas resistance training and high-intensity interval training tend to produce more stable glycemic profiles when appropriately managed. These findings underscore the importance of individualized exercise prescription, glucose monitoring, and patient education in this population.

### 3.6. Oxidative Stress, Inflammation, and Autonomic Function

Chronic low-grade inflammation and increased oxidative stress play a central role in the pathogenesis of insulin resistance and diabetes-related complications. The reviewed evidence

demonstrates that regular physical activity reduces markers of systemic inflammation and enhances endogenous antioxidant defense mechanisms.

Exercise training improves redox balance, reduces oxidative damage to lipids and proteins, and attenuates inflammatory signaling pathways in skeletal muscle, adipose tissue, and vascular endothelium. These effects are observed in both type 1 and type 2 diabetes and contribute to improved metabolic and vascular function.

Several studies also report improvements in autonomic nervous system function with regular physical activity, particularly in individuals with obesity and diabetes. Enhanced heart rate variability and improved autonomic balance are associated with reduced cardiovascular risk and improved overall prognosis.

### 3.7. Influence on Diabetes-Related Complications

The reviewed literature indicates that physical activity plays an important role in mitigating the progression of diabetes-related microvascular and macrovascular complications. Regular physical activity improves endothelial function, reduces arterial stiffness, and enhances myocardial performance, thereby reducing cardiovascular morbidity and mortality.

In individuals with diabetes-related kidney disease, physical activity has been associated with improved renal hemodynamics and slower disease progression. Exercise interventions have also been shown to reduce the risk of lower-extremity complications, including neuropathy-related functional impairment and amputation.

Collectively, these findings suggest that the benefits of physical activity extend beyond glycemic control to encompass long-term organ protection and improved survival in individuals with diabetes mellitus.

## 4. Discussion

The present narrative review provides a comprehensive synthesis of current evidence regarding the role of physical activity in the prevention and control of diabetes mellitus. The findings consistently demonstrate that physical activity exerts broad and multifaceted benefits across the entire spectrum of glucose metabolism, from diabetes prevention in high-risk populations to metabolic control and complication management in individuals with established disease. Importantly, these benefits extend beyond glycemic regulation and encompass improvements in cardiovascular health, body composition, skeletal muscle function, inflammatory status, and overall functional capacity.

One of the most robust and clinically relevant findings emerging from the reviewed literature is the strong preventive effect of physical activity against the development of type 2 diabetes mellitus. The magnitude of risk reduction observed in physically active individuals is substantial and comparable to that achieved with pharmacological interventions. This underscores the central role of physical inactivity as a proximal behavioral driver of insulin resistance and highlights physical activity as a primary target for population-level prevention strategies. Notably, the preventive benefits of physical activity appear to be largely independent of weight loss, emphasizing the importance of exercise-induced metabolic adaptations rather than changes in body mass alone.

In individuals with established type 2 diabetes, regular physical activity consistently improves glycemic control, as reflected by reductions in HbA1c, fasting glucose, and postprandial glucose excursions. The reviewed evidence suggests that combined aerobic and resistance training programs provide superior metabolic benefits compared with either modality alone. Aerobic exercise primarily enhances insulin sensitivity and glucose uptake, whereas resistance training increases skeletal muscle mass and improves basal glucose disposal capacity. The complementary nature of these adaptations supports current recommendations advocating multimodal exercise interventions in diabetes management.

The effects of physical activity in type 1 diabetes mellitus are more complex and require careful interpretation. While reductions in HbA1c are less consistent than in type 2 diabetes, regular physical activity improves insulin sensitivity, reduces daily insulin requirements, and decreases glycemic variability. These effects are clinically meaningful, particularly given the association between glycemic variability, oxidative stress, and long-term complications. The reviewed studies also highlight the importance of exercise modality, timing, and intensity in influencing glycemicresponses, underscoring the need for individualized exercise prescriptions and comprehensive patient education to minimize hypoglycemia risk.

Beyond glycemic outcomes, physical activity exerts profound effects on cardiovascular risk factors, which is of particular importance given that cardiovascular disease remains the leading cause of morbidity and mortality in individuals with diabetes. Improvements in blood pressure, lipid profile, endothelial function, and autonomic balance collectively contribute to a more favorable cardiovascular risk profile. These findings support the concept of physical activity as a “multisystem therapy” capable of addressing multiple pathophysiological pathways simultaneously.

The anti-inflammatory and antioxidant effects of regular physical activity represent additional mechanisms through which exercise contributes to diabetes prevention and control. Chronic

low-grade inflammation and oxidative stress are central features of insulin resistance and diabetes-related complications. Exercise-induced improvements in redox balance and inflammatory signaling may therefore play a critical role in slowing disease progression and reducing organ damage. Importantly, these adaptations are observed in both type 1 and type 2 diabetes, further supporting the universal relevance of physical activity across diabetes subtypes.

Despite the compelling evidence supporting physical activity as a cornerstone of diabetes prevention and management, its implementation in routine clinical practice remains suboptimal. Several barriers have been identified, including limited time during medical consultations, lack of structured exercise referral programs, insufficient training of healthcare professionals in exercise prescription, and patient-related factors such as fear of hypoglycemia, low motivation, and comorbid conditions. Addressing these barriers requires a multidisciplinary approach that integrates physicians, exercise professionals, diabetes educators, and public health systems.

From a public health perspective, increasing physical activity at the population level represents a cost-effective strategy with the potential to substantially reduce the global burden of diabetes. Even modest increases in daily physical activity can yield meaningful health benefits, suggesting that large-scale interventions promoting active lifestyles may have significant preventive impact. At the same time, targeted, supervised exercise programs are particularly important for individuals with established diabetes and those with advanced complications.

Several limitations of the reviewed evidence should be acknowledged. As a narrative review, this article does not include formal meta-analytic procedures, and heterogeneity in study design, exercise interventions, and outcome measures limits direct comparisons across studies. Additionally, many studies rely on self-reported physical activity, which may be subject to measurement bias. Future research should focus on long-term randomized controlled trials, standardized exercise protocols, and objective measures of physical activity and metabolic outcomes.

Further investigation is also needed to optimize exercise prescriptions for specific subgroups, including older adults, individuals with advanced diabetes complications, and those with multiple comorbidities. The integration of digital health technologies, such as continuous glucose monitoring and wearable activity trackers, holds promise for enhancing the safety, personalization, and adherence of physical activity interventions in diabetes care.

## 5. Conclusions

Physical activity plays a fundamental role in both the prevention and control of diabetes mellitus. The available evidence demonstrates that regular physical activity substantially reduces the risk of developing type 2 diabetes, improves glycemic control and insulin sensitivity in individuals with established disease, and attenuates the progression of diabetes-related complications. These benefits extend beyond glucose regulation and encompass improvements in cardiovascular health, body composition, inflammatory status, and functional capacity.

Given its broad physiological effects, favorable safety profile, and cost-effectiveness, physical activity should be regarded as a core therapeutic component of diabetes prevention strategies and routine clinical management. Healthcare systems should prioritize the systematic integration of structured physical activity interventions alongside pharmacological treatment and nutritional counseling. Future efforts should focus on improving implementation, adherence, and personalization of physical activity programs to maximize their long-term benefits for individuals at risk of or living with diabetes mellitus.

## Disclosure

### Author's contribution

Conceptualization: [WW], [KW]
Methodology: [JM], [PZ], [WW]
Check: [EC], [JB], [KW]
Investigation: [JB, IZ], [WW]
Data curation: [JM], [KW], [PZ], [JB]
Writing - rough preparation: [IZ], [EC], [WW]
Writing - review and editing: [PZ], [WW]
Visualization: [JB], [EC], [IZ]
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## Conflict Of Interest

The authors declare no conflict of interest.

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