

High-Intensity Interval Training and Diabetes Mellitus

Noorah Saleh Al-Sowayan¹ , Rahimah Zakaria² 

¹Department of Biology, Faculty of Science, Qassim University, Buraydah, Saudi Arabia; ²Department of Physiology, School of Medical Sciences, Universiti Sains Malaysia, Kubang Kerian, Malaysia

Correspondence to: Noorah Saleh Al-Sowayan, nsaoiean@qu.edu.sa, knaaj1@yahoo.com

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ABSTRACT

Background: Diabetes mellitus often develops on the background of insulin resistance. High-intensity interval training (HIIT) is included in the treatment of diabetes mellitus since it increases the sensitivity of tissues to insulin. **Objective:** This paper aimed to review published articles on the effects of HIIT on insulin resistance in diabetic patients. **Method:** A narrative literature review was undertaken. This review provides evidence from human studies, which highlights the beneficial effects of HIIT in both T1DM and T2DM patients. **Conclusion:** HIIT is generally safe and effective for people with diabetes mellitus and warrants further exploration.

1. INTRODUCTION

Protecting one's health is everyone's immediate responsibility. Still, many people prefer to lead the wrong lifestyle, have bad habits, and "kill" their health. Today, health is the most important human need that determines people's ability to live and work. In addition, health is an important factor in active knowledge of the world around us and human happiness. However, today, many people are reluctant to take care of their health, which leads to various pathologies, one of the most popular among which is diabetes. Diabetes mellitus (DM) has been known to humanity since ancient times, and the very name "diabetes" was introduced into medical practice by Aretaeus of Cappadocia in the 2nd century AD [1]. Diabetes mellitus is a disease of endocrine nature caused by an absolute or relative lack of insulin, a hormone of the pancreas. As a result of insulin deficiency, glucose metabolism is disrupted, and instead of being absorbed by the body's cells, it begins to accumulate in the blood. Tissues in the absence of glucose experience energy hunger and begin to die [2]. The disease can lead to the development of several serious defects.

Diabetes mellitus can be divided into Type 1 diabetes mellitus (autoimmune, T1DM) and Type 2 diabetes mellitus (T2DM). T1DM is most common in patients under the age of 30 and is more likely to develop as a result of the pancreas starting to malfunction due to a viral infection or toxins [3]. T2DM develops due to several reasons, the most common of which is obesity, leading to impaired tissue sensi-

tivity to insulin [4]. The main difference between type 2 diabetes is the immunity of body cells to the action of the hormone insulin, that is, their insulin resistance. In a healthy person, insulin “gives a command” to the cell membranes of various tissues to “let in” glucose—the main source of energy. In an individual with T2DM, the cells do not perceive the “commands” of insulin, and the membrane remains “locked” [4]. Insulin resistance (IR) and diabetes mellitus are two pathologies that are growing at an exponential rate around the world [4]. Diabetes treatment includes three main components—insulin, oral hypoglycemic drugs and diet therapy, self-monitoring of blood glucose levels, and physical exercises. However, some studies show that high-intensity exercise has a positive effect on diabetic patients by reducing IR.

2. CONCEPT OF INSULIN RESISTANCE

Insulin, a polypeptide hormone, consists of 51 amino acids. The nutrient content of meals causes pancreatic β -cells to produce insulin. Insulin binds to its membrane-bound receptor of target cells to coordinate an integrated anabolic response to nutrient availability, which inhibits fat cell lipolysis and hepatic glucose output while boosting glucose uptake into muscle and adipocytes [5].

The term IR was first coined to explain the considerable variability in insulin dose necessary to lower high glucose levels in T2DM patients [6], and later the term is used to describe the degree of change in blood glucose level after administration of a specific amount of insulin and glucose [7]. IR is defined as a complicated pathological state characterized by an inappropriate cellular response to insulin hormone [8]. Insulin's capacity to reduce hepatic glucose production and promote glucose absorption into muscle and adipose cells is impaired in persons with IR [9].

In the process of evolution, when periods of feeding alternated with periods of fasted, IR was originally an adaptation mechanism [10]. However, today, when eating a large number of calories, refined food, and physical inactivity, the opposite effect is observed—the development of various pathological conditions. Various factors affect tissue sensitivity to insulin. In addition to type 2 diabetes mellitus (T2DM), which most often occurs against the background of existing IR, there are several other diseases and conditions associated with this phenomenon [4]. Endocrine pathologies associated with IR include polycystic ovary syndrome in women and erectile dysfunction in men, thyrotoxicosis, hypothyroidism, Itsenko-Cushing's syndrome, acromegaly, pheochromocytoma, T1DM decompensation [11]. Non-endocrine diseases in the development of which insulin resistance plays a role include ischemic heart disease, arterial hypertension, chronic kidney disease, and others [11]. At the heart of IR is a violation of both receptor and post-receptor mechanisms of insulin signal transmission. Thus, a decrease in tissue sensitivity to insulin can be both a physiological response of the body to stress factors and a pathological process.

3. HIGH-INTENSITY EXERCISE

Low cardiorespiratory fitness is a well-known risk factor for chronic diseases like heart disease, T2DM and obesity, and is a key predictor of death among diabetics [12-14]. Physical activity and exercise, on the other hand, provide a wide range of health benefits, including improved cardiorespiratory fitness, energy balance, psychological well-being, immune function, strength, and flexibility, making it the most important means of improving overall health and well-being for people of all ages [15, 16].

High-intensity interval training (HIIT) is defined as alternating intervals of strenuous activity (defined as exercising at 70% of maximum aerobic capacity) with periods of rest or recovery (Figure 1). It is an effective technique for implementing strenuous exercise in unfit or unaccustomed to vigorous-intensity physical activity individuals [17]. It is also known for its ability to significantly improve several aspects of cardiometabolic health [18].

However, comparing HIIT studies is intrinsically problematic because numerous different HIIT protocols have been used, with varying numbers, intensities, and lengths of vigorous-intensity parts and/or recovery periods. Table 1 summarized the recommended optimal HIIT regimen based on the findings of a meta-analysis of research in participants with lifestyle-related metabolic illness [17].

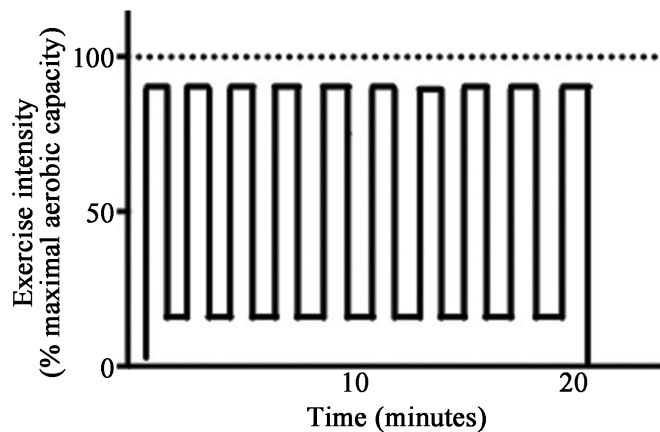


Figure 1. The HIIT protocol is depicted graphically [17].

Table 1. Protocol recommendations for HIIT [17].

| | |
|----------------|--|
| Frequency | 3 times per week |
| Duration | 40 min |
| Modality | Treadmill/hill, cycle ergometer. Increasing speed or incline |
| Intensity | Interval = 85% - 95% PHR Rest = passive 70% PHR |
| Interval times | 4 × 4 min intervals 3 × 3 min recovery |
| Warm-up | 10 min at 60% PHR |
| Cool-down | 5 min at 50% PHR |

PHR, peak heart rate.

4. HIGH-INTENSITY EXERCISE AND DIABETES MELLITUS

Most T1DM patients do not engage in sufficient regular physical activity (PA), mainly due to fear of hypoglycemia and impaired glycemic control, as well as social reasons such as lack of time, infrastructure, fatigue, and high training costs. As a result, about 60% of patients with T1DM are overweight or obese, about 40% suffer from hypertension, and about 60% have dyslipidemia [19]. Taking carbohydrates before and during exercise and adjusting the insulin dose are effective ways to prevent hypoglycemia but are not always sufficient. A bulky snack or a pronounced decrease in the dose of insulin may lead to hyperglycemia [19]. Continuous glucose monitoring (CGM) is a useful approach in T1DM patients who undergo HIIT programs [20]. High-intensity exercise training is well-tolerated, metabolically safe [21], reduced metabolic destabilization (of lactate, H⁺, glycogenolysis/glycolysis, and ATP) during intense exercise, and enhanced muscle oxidative metabolism in young adults with T1DM [22]. Lee *et al.* (2020) [23], however, showed no significant reduction in HbA1c with a 12-week HIIT intervention in adults with T1DM. However, glycemic control may improve for the subjects who undertake HIIT with greater adherence.

The American Diabetes Association published a position statement that listed HIIT as an alternate type of training that has been shown to improve insulin sensitivity and glycemic control in T2DM patients [24]. In addition, HIIT is an effective technique for decreasing cardiometabolic risk and preventing T2DM in prediabetic patients [25]. Acute HIT has been shown to reduce hyperglycemia, and postprandial hyper-

glycemia, and has the potential to improve glycaemic control in T2DM [26]. A similar study by Little *et al.* (2014) [27] demonstrated that a single HIIT session has greater and longer effects on reducing postprandial hyperglycemia when compared to continuous moderate-intensity exercise (CMI). In another study by Lee *et al.* (2015) [28], a 12-week high-intensity exercise program resulted in more positive changes in glycemic control (fasting glucose, C-peptide, homeostasis model assessment 2 of insulin resistance; $P \leq 0.05$) than a typical low-intensity exercise program in T2DM patients. Fealy *et al.* (2018) [29] reported that functional HIT may be a beneficial exercise modality for controlling T2DM since it improved insulin sensitivity in overweight/obese persons with T2DM, similar to improvements seen following more standard aerobic exercise programs. However, a study by Ahmad (2019) [30] concluded that less physically demanding moderate-intensity continuous training (MICT) is as good as HIIT for normalizing hyperglycemia in T2DM females.

5. CONCLUSION

Based on the available evidence, HIIT is generally safe and effective for people with T1DM and T2DM. However, more research in this field is needed to resolve the discrepancies in the outcomes of previous studies.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this paper.

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