Review Article

Beyond Blood Sugar: The Effects of Weight Change on HbA1c and Diabetes

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Abstract: Diabetes, a chronic disease characterised by hyperglycaemia, affects millions worldwide. Despite various treatments, weight management may affect the complications of disease. Weight gain and diabetes have been researched for decades. This review examined the relationship between weight loss and HbA1c level improvements among diabetes, the effects of weight loss on other diabetes outcomes, the factors of individual response to weight management, long-term HbA1c control, and the conditions under which weight reduction may be effective. Hence, diabetes, weight change, HbA1c, and other MeSH terms and keywords were searched in PubMed, Medline, EMBASE, Cochrane Library, Scopus, and CINAHL. We cross-referenced relevant articles' reference lists and intensively searched grey literature including conference proceedings, preprints, government reports, and institutional research papers. This research reveals that diabetics' HbA1c control improves with sustained weight loss. Despite individual variation and restrictions, the findings underline the need of weight management in diabetes therapy. The findings emphasis the need of including weight-management strategies into comprehensive diabetes treatment plans, while acknowledging both individual differences and constraints. Subsequent studies should include these characteristics and modify the suggestions appropriately, while also evaluating the long-term outcomes and determining effective strategies for achieving weight reduction in individuals with diabetes.

Keywords: Diabetes, HbA1c, Weight management, Insulin resistance, Glycaemia.

INTRODUCTION

Diabetes, a chronic condition characterised by elevated levels of glucose in the blood, presents significant health risks to a substantial number of individuals worldwide. Despite the existence of numerous potential treatments, weight management has emerged as a formidable tool that may even influence the course of the disease [1-4]. Concern regarding its impact on HbA1c, a primary indicator of glycaemic control, has sparked significant inquiries regarding cause and effect, as well as the most effective course of action.

In individuals with type 2 diabetes, weight loss is positively correlated with HbA1c reductions, according to numerous studies. The extent of this benefit appears to be proportional to the dosage; as weight loss increases, so does the reduction in HbA1c. The matter is intricate, nonetheless, as individual responses to weight loss are contingent upon factors such as genotype, lifestyle, and baseline HbA1c [5-9]. Furthermore, the duration of sustainable weight reduction is a critical determinant in both the maintenance of HbA1c control and the acquisition of enduring health advantages.

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A strong correlation has been established between body weight and diabetes. There is evidence to suggest that obesity, particularly in the form of abdominal fat, impairs insulin's functionality, thereby diminishing the body's efficient utilisation of sugar [10-12]. This facilitates the development of hyperglycemia and potentially progresses to type 2 diabetes. Conversely, weight loss resulting in decrease blood sugar.

The improvement of HbA1c levels due to weight loss stands as an important element in diabetes management according to multiple research papers. Previous investigations dedicated their research to short-term weight loss effects on HbA1c yet they explored weakly the durability of such improvements [13]. Studies conducted with randomized controlled trials showed weight loss leads to better glycemic control but these research conditions fail to replicate standard patient environments. Hence, research findings do not achieve external validity because of broader populations [14].

Past research studies have limitations because they analyzed different weight loss intervention types. A challenge exists when trying to reach combined conclusions because weight loss studies utilizes different dietary structures and both pharmacological treatments and surgical weight reduction methods [15]. Study examining weight loss effects on diabetes patients with comorbidities has limited success in generalizing findings because

multiple studies tend to exclude these subjects [16].

Taking all together, this review aims to evaluate the existing research evidence and provide insights into the correlation between varying degrees of weight loss and improvements in HbA1c levels among diabetes analysing findings from clinical trials, observational studies that report HbA1c changes in response to different weight loss, to identify the impact of weight loss on other diabetes-related outcomes (e.g., medication requirements and risk of complications), to explore determinants of individual response to weight management, long-term HbA1c control, and the circumstances under which weight reduction may be effective. This study was systematically examined using PRISMA and Risk of Bias techniques from Cochrane to clear, effective understanding of diabetes and weight change.

MATERIALS AND METHODS

This study employed with electronic resources, including PubMed, Medline, EMBASE, Cochrane Library, Scopus, and CINAHL by incorporating MeSH terms and keywords that are relevant to diabetes, weight change, HbA1c, and other relevant subtopics. Further examples subsequent search query include “weight gain" or "weight loss" AND ("glycemic control" or "HbA1c" AND "diabetes" AND "type 1/type 2". By employing a snowballing approach, relevant papers' reference lists were cross-referenced in conjunction with an exhaustive search of grey literature sources (Table **1**).

All included studies have been published in the English language and only full-text articles were included, excluding conference abstracts and other incomplete sources available for review within 2013–2023. Detailed explanations of weight change interventions and HbA1c measurement methodologies are also required. However, case reports, editorials, letters and studies that predominantly examined outcomes other than HbA1c were omitted from the analysis. Additionally, studies that lacked sufficient data or contained methodological flaws were excluded.

The PRISMA flowchart illustrates the study selection process (Fig. **1**). Studies relating weight change interventions to HbA1c were identified through a thorough search of the literature. In the initial, we found 250 studies in electronic databases and after searching the grey literature and using snowballing, we found another 30 records, combined with the first set for a total of 280 records. Once we removed duplicates, there were 230 separate records left to screen for the title and abstract. During this round of screening, 25 articles were omitted because they were not relevant, used a different language or were present more than once. We reviewed 205 complete articles to see if they met the inclusion and exclusion criteria we had set in advance. From among these, 112 studies were not included, since they did not look at HbA1c, were case reports, editorials, letters, conference abstracts, had important flaws or did not provide enough information on weight change. After the screening, just under 100 studies met the criteria. Of these, 73 were considered eligible and included in the final review.

Moreover, Cochrane Risk of Bias tool was used to check the study’s methods. The 100 studies demonstrated that they had little risk in selecting patients and reporting outcomes, except 27 studies, that had unclear or high risk in the blinding process.

Two reviewers independently assessed the titles and abstracts in order to identify papers that fulfilled the inclusion criteria. Conflicts were resolved through discussion or by consultation with the opinion of a third reviewer.

Table 1. Boolean Operators & Modifiers.

Database	Search Terms	Boolean Operators & Modifiers	Filters Applied
PubMed	("Weight loss" OR "Body weight reduction") AND ("HbA1c" OR "Glycated hemoglobin") AND ("Diabetes" OR "Type 2 diabetes" OR "Type 1 diabetes")	AND, OR, " " (for phrase searching)	English language, last 10 years, human studies
Medline	("Weight reduction" OR "Obesity management") AND ("Glycemic control" OR "HbA1c improvement") AND ("Diabetes mellitus")	AND, OR, Truncation (*) for variations	Peer-reviewed journals, full-text articles
EMBASE	("Weight loss intervention" OR "Bariatric surgery" OR "Dietary modification") AND ("HbA1c change" OR "Glycemic index")	AND, OR, Wildcards (*) to include variations	Clinical trials, systematic reviews
Cochrane Library	("Weight management" OR "Lifestyle intervention") AND ("Diabetes control" OR "HbA1c outcome")	AND, OR	Systematic reviews, meta-analyses
Scopus	("Weight loss therapy" OR "Caloric restriction") AND ("Diabetes outcome" OR "HbA1c levels")	AND, OR	Published in the last 10 years, English language
CINAHL	("Dietary intervention" OR "Exercise intervention") AND ("HbA1c reduction") AND ("Diabetes mellitus")	AND, OR	Peer-reviewed studies, full text

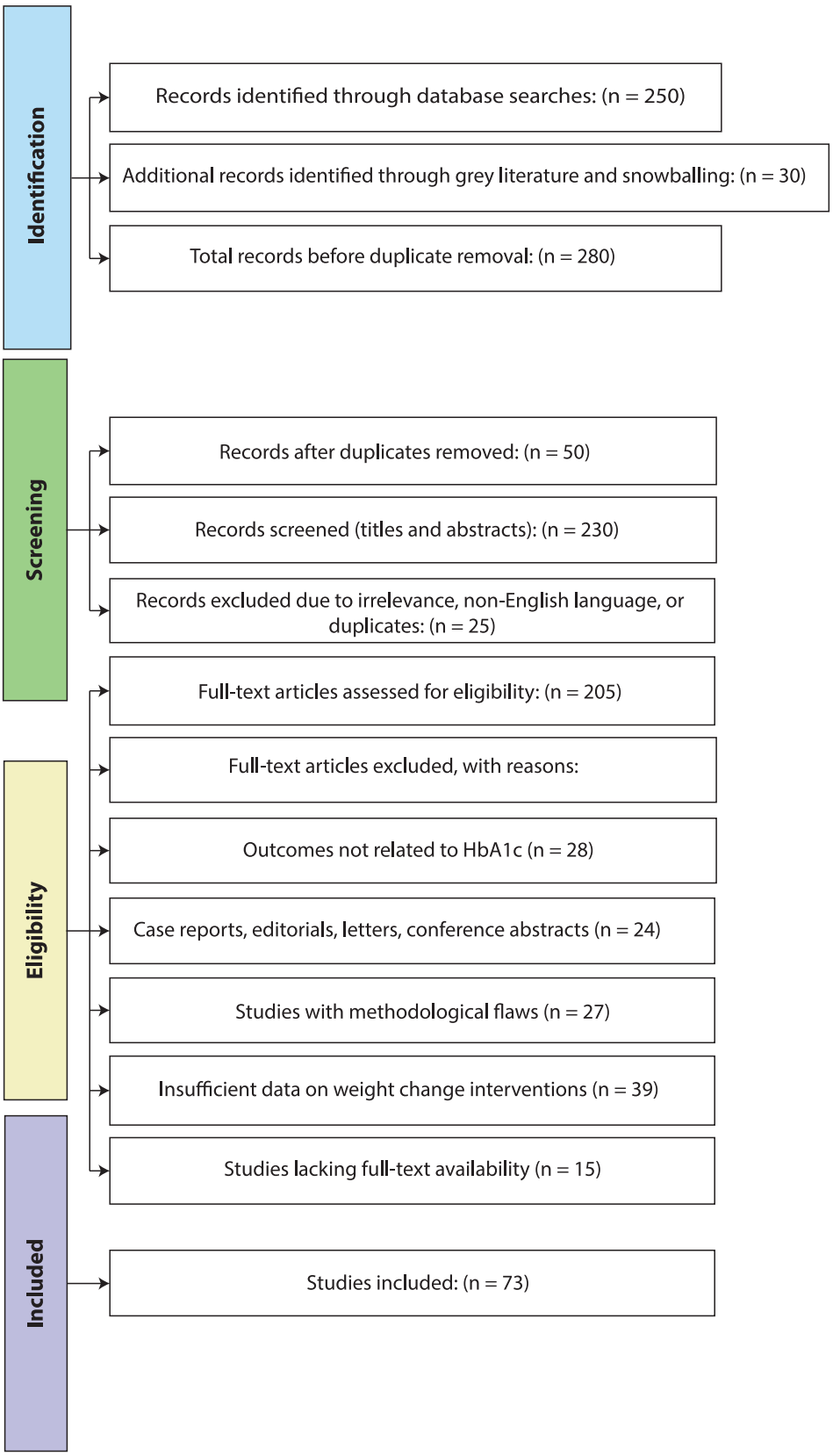

Fig. (1). PRISMA Flow Diagram Depicting Study Selection Process.

LITERATURE REVIEW

Effect of Weight Change on Normal HbA1C Level

Research indicates that individuals with diabetes often have improved HbA1c readings as a result of weight reduction. Generally, higher weight reductions tend to be more beneficial. A decrease of 5-10% in body weight may lead to improvements in HbA1c levels ranging from no change to a reduction of nearly 2%. Even modest weight losses can still have positive effects (1-5) on health [1-4]. The degree of improvement may vary somewhat depending on the type of diabetes, although both groups see potential improvements. But, not everyone with diabetes can normalize HbA1c levels after weight loss. Responses can be influenced by factors such as the type and severity of diabetes, genetics, or any related co-existing conditions [5-9]. Even after losing a significant amount of weight, some people with severe type 1 diabetes or long-term complications still need medication. The treatment of diabetes encompasses several intricate elements, including the regulation of body weight. Integrating a nutritious diet and consistent exercise into weight-loss endeavors might not only regulate blood sugar levels but also enhance long-term health results [17-19]. Successful weight loss can lead to a reduction in medication usage in patients diagnosed with type 2 diabetes appear to benefit the most from this strategy [20-22]. It demonstrates the advantage of improving quality of life and managing weight can be accomplished affordably. Maintaining regular communication with healthcare professionals can facilitate the effective management of diabetes in a methodical, practical, and health-oriented manner.

Taking all together, direct comparisons are challenging due to variations in research designs, demographics, and weight reduction methods. It is worth noting that several studies indicate an improvement in HbA1c as weight increases. Despite doing a thorough analysis of the papers included, there was significant disparity in the methodological rigour. Table **2** summarizes weight change effect on HbA1c in type 1 vs. type 2 diabetes.

Table 2. Comparison of Weight Change Effect on HbA1c in Type 1 vs. Type 2 Diabetes.

Parameter	Type 1 Diabetes	Type 2 Diabetes	References
HbA1c improvement with weight loss	Modest improvement; not all patients normalize HbA1c	Greater improvement; up to ~2% HbA1c reduction with 5–10% weight loss	[1-5]
Effect of 5–10% weight loss	Variable; improvement depends on severity and duration	Often leads to significant reduction in HbA1c and other metabolic parameters	[1-5], [20-22]
Response variability	Influenced by genetics, diabetes severity, and complications	Influenced by adherence, baseline weight, duration of diabetes	[5-9]
Need for medication after weight loss	Often continues due to insulin dependence and long-term complications	May reduce or eliminate need for glucose-lowering medication	[5-9], [20-22]
Impact of lifestyle modification	Benefits overall health but may not significantly alter insulin requirement	Strongly beneficial; improves glycemic control and may enhance insulin sensitivity	[17-19], [20-22]
Overall benefit from weight loss	Limited to moderate, especially in severe or long-standing cases	Substantial, with improved quality of life and reduced medication dependence	[1-5], [20-22]

Weight Loss and Diabetes-Related Outcomes

Weight loss has been shown to have a beneficial impact not only on HbA1c, but also on various other indices of diabetes. Numerous studies have documented that substantial reductions in diabetes medication usage would be the result of successful weight loss, with the majority of these reports focusing on type 2 diabetes [23-26]. This included oral medications; in extreme cases, some type 1 patients even eliminated insulin. The reduction percentage was patient-specific and dependent on the type of diabetes and the initial medication prescribed. Nevertheless, the possibility of decreasing drug dosage underscores the therapeutic benefits of cost savings and enhanced quality of life.

It has been demonstrated that weight loss reduces the risk of complications associated with diabetes. There was a reduction in the incidence of heart disease, stroke, and peripheral arterial disease, according to studies [27-29]. A reduced likelihood of kidney failure and a delayed progression of diabetic nephropathy were both outcomes of weight loss [30-32]. After weight loss, enhanced nerve function and decreased pain were observed in some studies. Despite the paucity of firm evidence, a number of studies have indicated possible eye health benefits [33, 34]. The degree of weight loss is likely to be proportional to the extent of risk reduction. Greater reductions in the risk of complications are generally correlated with more substantial reductions in body weight. Sustained compliance with weight management practices is essential for ongoing mitigation of risks. Weight loss was associated with enhanced sleep quality and decreased diurnal lethargy in individuals with diabetes, according to a number of studies [35-37]. Additionally, individuals with diabetes benefit from weight loss in terms of disposition, self-esteem, and gen-

eral health [38-40]. In addition, weight loss motivates individuals with diabetes to engage in more physical activity, which is advantageous for their overall health and glycaemic control [41, 42].

However, several studies have shown that enhancing glycaemic control by weight loss has not definitively decreased significant cardiovascular events, such as heart attacks or strokes [43-48]. Moreover, the study on the impact of weight loss on retinopathy, which refers to micro-vascular damage to the eyes, presents conflicting findings [49-52]. Deciding what is optimal for an individual based only on the outcomes of a single experiment or another is not straightforward, since individual patient characteristics and the design of the research may significantly influence the findings.

Due to the diversity of study populations and designs, it is challenging to compare and extrapolate findings. Nevertheless, the plethora of positive results reported in numerous studies indicates that the general trajectory is optimistic. It is highly probable that weight loss correlates with improved outcomes, including elevated insulin sensitivity levels, diminished edoema indicators, and advantageous modifications in blood pressure and lipid profiles. Further research is required to determine the optimal weight loss target in relation to specific outcomes and the long-term impacts of weight management on particular complications. Table **3** summarize the effects of weight loss and diabetes-related outcomes in Type 1 vs. Type 2 diabetes.

Table 3. Comparative Effects of Weight loss and Diabetes-Related Outcomes in Type 1 vs. Type 2 Diabetes.

Clinical Outcome	Type 1 Diabetes	Type 2 Diabetes	References
Reduction in medication usage	Rare; some cases show reduced insulin needs	Common; many patients reduce or discontinue oral hypoglycemics	[23-26]
Complete discontinuation of medication	Rare and extreme cases	Frequently reported with substantial weight loss	[23-26]
Cardiovascular risk reduction	Less consistently reported; some studies show benefit	Strong evidence of reduced risk for heart disease, stroke, PAD	[27-29]
Renal outcomes (nephropathy)	Possible delay in progression	Significant reduction in risk and delayed onset	[30-32]
Neuropathy improvement	Some studies show improved nerve function and reduced pain	Consistent reports of neuropathy improvement	[30-32]
Retinopathy (eye complications)	Conflicting evidence	Mixed findings; some improvement, but not conclusive	[33-34], [49-52]
Sleep quality and lethargy	May improve, but less studied	Notable improvements in sleep and reduced daytime fatigue	[35-37]
Mental health and self-esteem	May improve with better glycemic control and weight image	Strong improvement in mood, self-esteem, and overall well-being	[38–40]
Physical activity motivation	Enhanced motivation may occur post-weight loss	Strong association with increased activity and improved glycemic control	[41–42]
Major cardiovascular events (e.g., MI, stroke)	No definitive reduction confirmed	Mixed evidence; no consistent reduction in major events	[43–48]

Factors and Sustainable Weight Management

Several studies suggest that those with elevated initial HbA1c levels have the potential to achieve the most significant decrease in HbA1c by decreasing weight [1-4]. While type 2 diabetes, which is characterised by insulin resistance, has a more pronounced HbA1c response to weight reduction compared to type 1 diabetes [53-55]. Elevated blood glucose levels might provide challenges. Genetic variants are believed to be associated with obesity and metabolism. Specifically, differences in particular genes may impact the efficacy of weight reduction efforts and their effect on reducing HbA1c levels and wrist measures [55-57]. The effects of weight reduction and changes in HbA1c levels vary depending on the level of activity, including adherence or non-adherence to diet and exercise routines [58-60]. Motivation, self-efficacy, and coping mechanisms are crucial factors in sustaining weight reduction and adhering to weight control strategies [61-63]. Thyroid problems or sleep apnea may have an impact on weight reduction and HbA1c results [64-66].

Regaining weight after an initial loss undo the benefits in HbA1c levels and raise the risk of problems [67, 68]. Sustaining optimal glucose control necessitates continuous endeavours towards adopting a healthy dietary regimen and engaging in heightened levels of physical exercise. Maintaining a healthy weight leads to a substantial decrease in the likelihood of experiencing severe consequences related to diabetes, such as cardiovascular disease, renal disease, and neuropathy [67, 69]. Long-term weight

management is associated with the correlation between adequate sleep, enhanced mobility, elevated energy levels, and heightened self-esteem, all of which contribute to improved overall health.

Taking all together, to achieve optimal weight distribution and maximise efficiency, it is crucial to identify and treat each unique response element. Implementing lifestyle modifications aimed at reducing obesity, together with participating in group support and action programmes, may effectively assist individuals in maintaining their progress over an extended period and achieving more favourable results in terms of weight reduction. Finally, multiple research has found nobody can sustain weight decrease for life. The aforementioned research has also emphasised the associated health advantages of long-term weight reduction maintenance.

A direct correlation was seen between the amount of weight reduction and the improvement in HbA1c levels in individuals with both type 1 and type 2 diabetes. While it is possible that type 2 patients may have somewhat greater benefits, it is important to note that even persons with type 1 diabetes might get some advantages from enhanced glycemic control. These results align with other research that emphasises the many advantages of weight loss in diabetes, except only insulin sensitivity.

The relevance of the current research findings is mitigated due to the challenges in making direct comparisons caused by variances in study design, demographics, and treatments. Further scrutiny is required to thoroughly evaluate the indicated quality evaluation methodologies and their influence on the researchers' overall findings. What is the optimal weight reduction goal for the various subtypes and HbA1c levels of diabetes, and currently there is no knowledge about the specific qualities that indicate a need to lose 5kgs vs a need to lose a significant amount of weight.

The effectiveness of different weight control approaches and their long-term outcomes have not yet been determined with certainty. Further investigation is required, specifically to see whether pursuing that course of action will enable the management of individual HbA1c levels while averting problems.

Simultaneously, it is important to investigate the correlation between genetic predispositions, particular lifestyle variables, weight reduction strategies, and their impact on individual responses. Furthermore, it is crucial to assess the cost-effectiveness and practicality of these sustainable weight control programmes in various hospital settings to ensure their broader acceptability and influence. Table **4** summarizes the factors and sustainable weight management in type 1 and Type 2 diabetes.

Table 4. Comparison of Factors and Sustainable Weight Management in Type 1 and Type 2 Diabetes.

Aspect	Type 1 Diabetes	Type 2 Diabetes	References
Response of HbA1c to Weight Reduction	Some benefit in glycemic control observed	More pronounced HbA1c response to weight loss	[53-55]
Initial HbA1c and Weight Reduction Effect	Individuals with high HbA1c may still benefit	High HbA1c levels linked with greater potential for HbA1c reduction	[1-4, 53-55]
Impact of Genetic Variants	Genetic predisposition may influence response, but specific effects unclear	Genetic differences may affect metabolism, weight reduction, and HbA1c change	[55-57]
Influence of Lifestyle (Diet, Exercise)	Adherence to lifestyle changes affects outcomes	Adherence to lifestyle changes affects outcomes	[58-60]
Influence of Psychological Factors (e.g., Motivation, Self-efficacy)	Crucial for sustaining weight control and glycemic outcomes	Crucial for sustaining weight control and glycemic outcomes	[61-63]
Comorbidities (e.g., Sleep Apnea, Thyroid Issues)	May complicate weight loss and HbA1c control	May complicate weight loss and HbA1c control	[64-66]
Risk of Weight Regain	Regain can undo glycemic benefits	Regain can undo glycemic benefits	[67-68]
Long-term Health Benefits of Weight Maintenance	Lower risk of complications (e.g., CVD, nephropathy, neuropathy) with weight control	Same; benefits include reduced risks of diabetes-related complications	[67, 69]
Sustainability of Weight Loss	Long-term maintenance difficult, requires individualised strategies	Long-term maintenance difficult, requires support programs	[67-69]

Obesity and Type 2 Diabetes Mellitus

Chronic low-grade inflammation directly impacts metabolic dysfunction because it exists as a close connection between obesity and type 2 diabetes mellitus (T2DM). Due to its active endocrine functioning adipose tissue mostly including visceral fat produces pro-inflammatory cytokines including tumour necrosis factor-alpha (TNF-α) interleukin-6 (IL-6) and C-reactive protein (CRP). Such inflammatory markers lead to insulin resistance and damage glucose metabolism while raising HbA1c levels [70].

A systematic reduction of body weight produces substantial decreases in biological inflammation that enhances blood sugar control. Scientific investigations show that achieving weight reduction between 5–10 % results in lower inflammatory cytokine levels and enhanced insulin response [13]. The decrease in adipose tissue mass is the primary factor that leads to reduced inflammatory mediator production and enhanced insulin-responsive tissue activity [71].

Weight loss therapy increases the key function of pancreatic beta cells since these cells produce insulin. The reduction of body weight leads to better glucose uptake in skeletal muscles combined with decreased hepatic glucose release which lowers both fasting blood sugar and HbA1c levels [72]. Studies indicates that combining dietary restrictions with physical exercise effectively lowers systemic inflammation together with having positive impacts on metabolic processes [73].

Weight reduction serves as an essential therapeutic method for diabetes management since obesity-related inflammation directly advances diabetes development. Future studies must analyze the long-term effects that sustained weight reduction creates on inflammatory indicators together with blood sugar outcomes for different communities of people.

The current study shows that successful weight management needs plans that fit each patient's needs, based on diabetes, beginning HbA1c level, psychological circumstances, and other health issues. To improve treatment, clinicians should combine lifestyle changes with psychological assistance. Dealing with thyroid disorders and sleep apnea may boost weight loss progress and better manage blood sugar. Programs involving dietitians, psychologists and exercise specialists help keep weight stable and lessen diabetes complications.

In future research, it would be important to decide optimal weight loss in different types of diabetes, while also trying to identify genetic or metabolic reasons. Some people may not respond well to weight loss. Studies are needed to compare weight management processes work over time, examine their affordability in several health settings and determine the optimal timing and duration of these interventions. Looking at sleep, energy levels and movement are related to blood sugar will clear the presence of more personal and comprehensive diabetes care.

CONCLUSION

This comprehensive analysis indicates that, above all, seeing a few very successful instances of early and sustained weight reduction will have a significant effect on HbA1c levels in those afflicted with diabetes, resulting in a greater number of people experiencing its detrimental effects. The findings emphasise the need of including weight-management strategies into comprehensive diabetes treatment plans, while acknowledging both individual differences and constraints. Subsequent studies should include these characteristics and modify the suggestions appropriately, while also evaluating the long-term outcomes and determining effective strategies for achieving weight reduction in individuals with diabetes (Table **5**).

Table 5. Effect of Weight Change on HbA1c and in Individual Effected with Diabetes.

Objective 1 Weight Change on HbA1c Level and Diabetes Mellitus		**References**
Effect of Weight Change on HbA1c Level		
Dose-dependent relationship	Larger weight losses were associated with more significant HbA1c improvements by medication.	[1-4]
Subtype variations	Greater benefits for type 2 diabetes than because of insulin resistance than type 1 diabetes	[5-9]
Individual variability	Baseline HbA1c, genetics, and lifestyle habits	[17-19]
Reduced medication	weight loss allowed for medication reduction or even discontinuation in some individuals, particularly those with type 2 diabetes	[20-22]
Cardiovascular events	No definitive decrease	[43-48]
Retinopathy	Conflicting findings	[49-52]
Objective 2 Weight loss and diabetes-related outcomes		
Reduced medication needs	Significantly reduced diabetes medication use, including oral meds and insulin in some cases. Reduction varies based on individual factors. Individualized approach with healthcare professional supervision is crucial.	[23-26]
Diminished risk of complications	Cardiovascular complications (heart disease, stroke, peripheral arterial disease)	[27-29]
	Kidney complications (diabetic nephropathy, kidney failure)	[30-32]
	Neuropathy (nerve damage, pain)	
	Retinopathy (eye disease)	[33, 34]

Improved sleep	Better sleep quality and reduced daytime sleepiness.	[35-37]
Psychological benefits	Improve mood, self-esteem, and overall quality of life.	[38-40]
Increased physical activity	Weight loss can make physical activity easier and more motivating, further benefiting health and glycemic control.	[41, 42]
Objective 3 Factors Influencing Response to Weight Loss in Diabetes		
Diabetes Type	Type 2 (insulin resistance) respond better than Type 1.	[53-55]
Genetics	Variations in obesity & metabolism genes can influence weight loss & HbA1c.	[55-57]
Lifestyle Habits	Diet, physical activity, and sleep impact weight loss & HbA1c.	[58-60]
Psychological Factors	Motivation, self-efficacy, and coping mechanisms are key.	[61-63]
Comorbidities	Underlying health conditions, such as thyroid can affect weight loss & HbA1c.	[64-66]
Importance of Sustainable Weight Management for HbA1c and Diabetes Mellitus		
Maintaining HbA1c Control	Sustained weight loss is crucial for long-term glycemic control.	[67, 68]
Long-Term Health Benefits	Sustained weight loss offers lasting positive health effects.	[67, 69]

AUTHORS' CONTRIBUTION

Syed Azar Hussain Zaidi: Conceptualization, Study Design, Methodology, Data analysis and interpretation, Writing Draft, Critical review and revision the manuscript, Final approval, final proof to be published.

Syed Amjad Ali: Conceptualization, Study Design, Methodology, Data analysis and interpretation, Writing Draft, Critical review and revision the manuscript, Final approval, final proof to be published.

Imtiaz Ahmad and Inayat Ullah: Conceptualization, Study Design, Methodology, Data analysis and interpretation, Writing Draft, Critical review and revision the manuscript.

Aurang Zeb: Study Design, Writing Draft, Critical review and revision the manuscript, Final approval, final proof to be published.

Ambreen Saadat: Study Design, Writing Draft, Critical review and revision the manuscript.

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Ethical Approval

Not applicable.

Consent to Participate

Not applicable.

Consent for Publication

Consented.

Conflict of Interest

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Competing Interest/Funding

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Use of AI-Assisted Technologies

The authors declare that no generative artificial intelligence (AI) or AI-assisted technologies were utilized in the writing of this manuscript, in the creation of images/graphics/tables/captions, or in any other aspect of its preparation.

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