

https://dspace.org/

The Effectiveness of Strength Training Programs on Quality of Life in Adults with Type 2 Diabetes: A Systematic Review

Narandas, Ulaysha Ramlakan

2025
University of the Witwatersrand, Johannesburg
https://hdl.handle.net/10539/49939

Narandas, Ulaysha Ramlakan. (2025). The Effectiveness of Strength Training Programs on Quality of Life in Adults with Type 2 Diabetes: A Systematic Review [Master's dissertation, University of the Witwatersrand, Johannesburg]. WIReDSpace. https://hdl.handle.net/10539/49939

Downloaded from a DSpace repository. https://dspace.org/

THE EFFECTIVENESS OF STRENGTH TRAINING PROGRAMS ON QUALITY OF LIFE IN ADULTS WITH TYPE 2 DIABETES: A SYSTEMATIC REVIEW

Ulaysha Ramlakan Narandas

Student Number: 0006415D

A Dissertation submitted to the Health Sciences, University of Witwatersrand, Johannesburg, in fulfilment of the requirements for the Master of Science in Physiotherapy.



Johannesburg, 2025

Declaration

I, Ulaysha R. Narandas declare that this Dissertation is my own, unaided work. It is being submitted for the Master's Degree in Physiotherapy at the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Ulaysha Ramlakan Narandas _____

Name of candidate Signature of candidate

17th day of October 2025 in Johannesburg.

Dedication

I dedicate this work to my husband, Yashil, for his unwavering love, patience, and encouragement, as well as to my children, Yuvar and Avara, whose smiles and presence infuse every endeavour with significance.

Lastly, I would like to extend my gratitude to my family and friends for their unwavering support throughout this process. This accomplishment is as much yours as it is mine.

Acknowledgements

I would like to express my deepest gratitude to my supervisors, Dr Natalie Benjamin-Damons and Dr Kganetso Sekome for their invaluable guidance, support and encouragement throughout this research journey. Their expertise and insightful feedback have been instrumental in shaping this systematic review.

Abstract

Introduction

Strength training has been identified as an effective intervention for the management of Type 2 Diabetes Mellitus (T2DM). Beyond improving glycemic control, strength training enhances muscle function, promotes metabolic health, and contributes to a better quality of life. Understanding the effectiveness of different strength training programs can help manage symptoms and reduce the complications associated with T2DM, thereby supporting better quality of life. It has been established that strength training can have a positive effect on health in individuals with T2DM. There is still a need to evaluate the overall effectiveness of strength training programs in adults with Type 2 diabetes. This review focusses on adults already diagnosed with T2DM and evaluates both structured and unstructured strength training programs to determine their effectiveness and sustainability.

.

Objectives

The objective of this review was to identify and compare different strength training programs and to evaluate the effectiveness in improving quality of life among adults with T2DM.

The review further recommends effective strategies to support adherence to strength training interventions for a better quality of life. The outcome measures report on the quality of life in adults 18 years and older, diagnosed with T2DM.

Methods

A systematic review was conducted. The databases searched included PubMed, SCOPUS, Cochrane Library, Embase, Science Direct (1 Jan 2012 to 30 June 2024). Critical appraisal was conducted using JBI tools, JBI checklist and a standardized extraction tool was utilized for data extraction. Narrative synthesis was applied given heterogeneity.

Results

The review identified that structured strength training programs, including resistance only and combined modalities with aerobic training significantly improved glycaemic control, reduced HbA1c levels, enhanced muscle strength, and improved health related quality of life. Unstructured programs, while less intensive, were associated with better adherence and long-term engagement. Eighteen studies from 10 countries were included, employing HRQoL measures such as SF-36, WHOQOL-BREF, and diabetes specific instruments. Findings indicated small-to-moderate improvements in physical functioning, vitality and overall HRQoL, with less consistent effects in psychological and social domains.

Conclusion

Strength Training programs are effective in improving physical and metabolic outcomes in adults with T2DM. Structured programs offer greater clinical benefits, while unstructured programs may enhance adherence. Both contribute meaningfully to better management and improved quality of life. Future research should focus on long term comparative effectiveness and strategies for integrating both approaches into Diabetes care models.

Keywords: Strength Training Programs, Quality of Life, Type 2 Diabetes.

Table of Contents

Declaration ii
Dedication iii
Acknowledgements iv
Abstract v
List of Tables ix
List of Figures ix
List of Appendices ix
List of Abbreviations x

Chapter 1 Introduction 1

1.1 Background 1
1.2 Problem Statement 7
1.3 Research Question 7
1.4 Aims and Objectives 7
1.5 Objectives of the Study 7
1.6 Significance of the Study 8
1.7 Outline of this Research Report/ Dissertation / Thesis 9

Chapter 2 Literature Review 11

2.1 Introduction 11
2.2 Structured and Unstructured Strength Training Programs 16
2.3 Critical Implication of Training Programs on Type 2 Diabetic Patients 18
2.4 Factors Influencing the Quality of Life in Type 2 Diabetic Patients 22
2.5 Literature Gap 32

Chapter 3 Methodology 35

3.1 Introduction 35
3.2 Study Design 36
3.3 Study Setting 37
3.4 Participants 37
3.5 Outcomes of Interest 40
3.6 Procedure 40
3.7 Ethical Considerations 44
3.8 Conclusion of the methodology 45

Chapter 4 Results 46

4.1 Introduction 46
4.2 Description of Studies 46
4.3 Methodological Quality Assessment 54
4.4 Sample 58
4.5 Participants 58
4.6 Interventions 59
Chapter 5 Discussion 73
5.1 Introduction 73
5.2 Effectiveness of strength training program 73
5.3 Impact on Quality of Life 74
5.4 Strength Training Programs for Patients with T2DM 75
Chapter 6: Conclusions and Recommendations 78
References 82
Appendix 89

List of Tables

Table 1 PICO Outline 38
Table 2 Description of JBI Appraisal Tool 42
Table 3 Inclusion Criteria Guideline Checklist 43
Table 4 Excluded Studies 47
Table 5 Included Studies 51
Table 6 RCT Critical Appraisal Scores 56
Table 7 Critical Appraisal of Eligible Systematic Review 57
Table 8 Summary of the findings 61
Table 9 Intervention type and frequency and duration of Enrolled Investigations 67

List of Figures

Figure 1-1 Outline of the thesis 9
Figure 2-1 Benefits of exercise in managing Type 2 diabetes to lead a quality life 27
Figure 2-2 Transtheoretical model of health behaviour change 31
Figure 3-1 Search strategy and outcome: PRISMA flow diagram 39

List of Appendices

Appendix A 89
Appendix B 90
Appendix C 91
Appendix D 93

List of Abbreviations

T2DM	Type 2 Diabetes Melitus
QoL	Quality of Life
WHO	World Health Organisation
DM	Diabetes Mellitus
DASH	Dietary Approaches to Stop Hypertension.
HIIT	High Intensity Interval Training
HBA1c	Glycated haemoglobin/Haemoglobin A1c
GLUT4	Insulin-sensitive glucose transporter
CBT	Cognitive Behavioural Therapy
MBSR	Mindfulness-Based Stress Reduction
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
JBI	Joanna Briggs Institute
DDS	Drug Delivery System

Chapter 1 Introduction

1.1 Background

Diabetes Mellitus is a chronic metabolic disease that hampers the ability to produce insulin, resulting in lower absorption of glucose in the blood (World Health Organization, 2023). Lower glucose absorption leads to an increase in the glucose levels in the blood. In 2021, approximately 10.5% of the global adult population was suffering from diabetes, and the percentage of diabetic adults is projected to be 12.2% in 2045 (Statista.com, 2022). The adult population between the age group of 65-99 is suffering from this disease the most (Merchant et al., 2022). In 2022, an estimated 828 million adults aged 18 years and older worldwide were living with diabetes, a significant increase from previous decades. This figure represents approximately 14% of the global adult population, doubling from about 7% in 1990. Notably, more than half approximately 59%of adults aged 30 years and over with diabetes were not receiving treatment for their condition. (World Health Organisation, 2024).

A study showed that in 2017, the number of people aged between 65-99 who were suffering from diabetes was assessed to be around 122.8 million (M Longo, et al., 2022). The same study articulated that the number is likely to increase and reach up to 200 million in the year 2045. The prevalence of diabetes mellitus has rapidly increased in South Africa, from 4.5% in 2010 to 12.7% in 2019 S. Mokhele (2024). Of the 4.58 million people aged 20–79 years who were estimated to have diabetes in South Africa in 2019, 52.4% were undiagnosed. (International Diabetes Federation, 2021).

There are primarily three Types of diabetes, which are called Type 1 diabetes, Type 2 diabetes and gestational diabetes which is only found in pregnant women. South Africa has the second highest number of people living with Type 2 diabetes in sub-Saharan Africa. (World Health Organization, 2016).

The rising number of diabetic patients in society is also putting stress on the healthcare sector. Zimmet, Alberti, and Shaw (2001), highlighted the global implications of the diabetes epidemic, emphasizing the burden it places on health systems. Being a diabetic individual means that they must constantly monitor their blood sugar levels, take medication, follow a strict diet, and maintain habits for leading a healthy lifestyle

(American Diabetes Association, 2020). Dietary restrictions increase for the person as they are unable to consume foods that will increase blood sugar levels (Colagiuri, Dickinson, & Kesson, 2013). The body, therefore, weakens, immunity reduces, and individuals become vulnerable to other diseases (Cavan & Harris, 2015).

There are three primary forms of diabetes: Type 1 diabetes, Type 2 diabetes, and gestational diabetes.

Type 1 Diabetes

Type 1 diabetes is an autoimmune condition where the body's immune system attacks the insulin-producing cells in the pancreas (American Diabetes Association, 2014). As a result, the body produces little to no insulin, a hormone necessary for regulating blood sugar levels. This type of diabetes is usually diagnosed in children and young adults, but it can occur at any age. People with Type 1 diabetes need to take insulin daily to manage their blood sugar levels. (https://www.cdc.gov/maternal-infant-health/pregnancy-diabetes/index.html)

Type 2 Diabetes

Type 2 diabetes is the most common form of diabetes. It occurs when the body becomes resistant to insulin or when the pancreas doesn't produce enough insulin (Centers for Disease Control and Prevention [CDC], 2022). This leads to high blood sugar levels. Type 2 diabetes is often associated with older age, obesity, family history, physical inactivity, and poor diet. It can sometimes be managed with lifestyle changes such as diet and exercise, but medication or insulin therapy may also be needed. (https://www.cdc.gov/maternal-infant-health/pregnancy-diabetes/index.html)

Gestational Diabetes

Gestational diabetes develops during pregnancy in women who did not have diabetes before becoming pregnant (Centers for Disease Control and Prevention [CDC], 2022). It usually appears in the second or third trimester and typically goes away after the baby is born. However, women who have had gestational diabetes are at higher risk of developing Type 2 diabetes later in life. Managing gestational diabetes involves

monitoring blood sugar levels, following a healthy diet, exercising, and sometimes taking medication (https://www.cdc.gov/diabetes/about/gestational-diabetes.html)

Beyond the immediate health concerns of diabetes, its impact extends to an individual's overall well-being and daily life. The increasing prevalence underscores the urgent need for effective interventions that improve health outcomes, reduce complications, and enhance quality of life for people living with T2DM.

Quality of Life (QoL) is defined by the World Health Organization as "an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns" (World Health Organization, 2020). When an individual becomes diabetic, their quality of life is significantly affected. The diabetic individuals may experience a gradual decline in health, as they may succumb to various other diseases. This may happen when their blood sugar levels are not well controlled. Looking at the clinical burden of diabetes, this results in an increased healthcare expenditures due to regular blood sugar monitoring, declining health outcomes, and ongoing costs related to medication. It is noted that, the rising number of diabetic patients in society is putting additional stress on the healthcare sector.

As a diabetic individual, constant monitoring of blood sugar levels is essential, along with adherence to prescribed medications and strict dietary guidelines. Dietary restrictions increase for these individuals, as they must avoid foods that can elevate their blood sugar levels. Consequently, if their blood sugar levels rise, this can lead to physical decline and a reduction in immunity, making them more vulnerable to other diseases.

Considering these challenges, incorporating strength training also known as resistance exercise can play a crucial role in improving health outcomes for individuals with diabetes. Strength training increases strength by making muscles work against a weight or force (Sundell, 2011). This form of exercise not only aids in weight loss but also improves metabolism this allows individuals to burn more calories. Common strength training exercises include high thrusts, squats, side twists, chest presses, and bent-over rows.

The Impact on Quality of Life

As a result of engaging in strength training, the body's capacity to respond to insulin improves, blood sugar utilization is enhanced, weight loss occurs, and the risk of heart disease decreases. Therefore, the quality of life for individuals with diabetes is positively affected, as their ability to perform everyday activities increases—activities that may have been disrupted due to their condition.

Research supports strength training as an effective way to reduce the risk of developing Type 2 diabetes and assist in managing the condition (García-Hermoso et al., 2020; American Diabetes Association, 2020). Shiroma et al (2017), established that women who participate in day-to-day strength training are at a lower risk of having diabetes compared to those women who do not. This research did not specify what types of strength training programs are necessary to help patients. Identifying the varieties and assessing the effectiveness of diverse strength training programs can considerably aid in decreasing the prevalence of Type 2 diabetes, modifying its impacts, and improving quality of life. Studies demonstrate that different strength training methods, including resistance training and high-intensity interval training, positively influence glycaemic management and insulin sensitivity in persons with Type 2 diabetes (García-Hermoso et al., 2020; American Diabetes Association, 2020). Strength training improves overall health outcomes, which is an essential aspect of quality of life. Regular strength training aids in weight management and enhances physical health, hence improving the quality of life for individuals with Type 2 diabetes (Kelley & Kelley, 2017). By utilising efficient strength training programs, healthcare providers can more effectively assist individuals in avoiding and controlling Type 2 diabetes while improving their overall well-being and quality of life.

Junior et al. (2017), explains that acute strength training promotes a positive change in white blood cell circulation levels of "miR-146a". The researchers stated that a positive change in the miR-146a level reduces insulin resistance in the body. This metabolic change decreases glucose levels in the blood. Furthermore, Silva et al. (2019), explains strength training assists the body by improving lipoprotein levels and resulting in reduced blood sugar level. The study of Barreiro and Howard (2017) established that an unstructured strength training programme ensures that mobility

among adult patients increases. The study concluded that the quality of evidence was low in determining the effects of unstructured strength training and there is no strong evidence that this programme helps to improve mobility in adult diabetic patients.

On the contrary, Shakil-ur-Rehman et al. (2017), showed that structured strength training programmes help to control the fasting glucose levels, and plasma insulin levels, and improve insulin resistance status in adults. As per the opinion of Fisher et al. (2017), effective behavioural changes and strategic frameworks help in battling diabetes and ensure that adult patients live a healthy life. The researcher proposed a three-step framework containing “diabetes relationship building”, “specific behavioural tools”, and “clinical encounters” that can help diabetic patients Campbell (2017), showed that planned eating habits can significantly aid in diabetes management. The researcher proposed an eating plan named “Dietary Approaches to Stop Hypertension” (DASH) to help patients with diabetes. The DASH diet highlights increase intake of fruits and vegetables, whole grains, and low -fat dairy and reducing salt intake. This is beneficial for hypertensive patients. However, this dietary approach also has important implications for diabetes management. The importance on whole, nutrient-dense food increases insulin sensitivity and regulates blood sugar levels, making this particularly beneficial for individuals with Type 2 diabetes. By promoting a balanced intake of essential nutrients and minimizing processed foods high in sugar and unhealthy fats, the DASH diet supports better glycaemic control and overall health. Adopting the DASH eating plan can be a valuable strategy for those managing diabetes, as it aligns with the goals of improving insulin sensitivity and promoting a healthier lifestyle.

As per the findings of Mishra et al. (2021), among the many strategies to control diabetes, “nanocarriers-based therapeutic DDS” is emerging as one of the most effective methods to incorporate “Metformin” to control diabetes. Metformin is known to be an efficient antidiabetic agent used in monotherapy at present, and with the help of nanotechnology, this agent can work more efficiently (Ajjan ,2017), stated that an effective monitoring system can help to reduce the rates of diabetes in adult patients. The research showed that glucose monitoring with a biotechnologically advanced “HbA1c” marker could help to assess blood glucose levels.

The literature indicates that individuals with Type 2 diabetes experience a lower quality of life (QoL) compared to healthy individuals (Gonzalez et al., 2016). Individuals with Type 1 diabetes who are on insulin therapy are less likely to develop cardiovascular diseases, however they are more susceptible to hypoglycaemia than those with Type 2 diabetes. This suggests that both conditions can lead to a compromised quality of life. Furthermore, poor quality of life is often predicted in individuals leading a sedentary lifestyle, which is a modifiable risk factor for Type 2 diabetes. Engaging in physical exercise has been shown to positively impact body composition, glycemic control, blood pressure, insulin resistance, and both the mental and physical aspects of QoL (Pablo Tomas et al., 2019).

Resistance training increases GLUT4 translocation within skeletal muscles, which thereby increases insulin sensitivity. This results in the restoration of metabolic flexibility. Resistance training also increases, energy expenditure, and in post-exercise conditions, oxygen consumption increases due to resistance training. These improvements in health therefore improve the quality of life for diabetic people. A previous systematic review assessed the effects of resistance training on quality of life in older adults aged 60 years and over, highlighting how resistance training impacts various factors such as muscle strength, insulin sensitivity, and overall metabolic health (Kashi et al, 2022).

To optimize strength training protocols for diabetic patients, further research is crucial to explore the long-term effects, adherence strategies, and individualized outcomes related to quality of life. Despite the growing evidence supporting the benefits of exercise for managing Type 2 diabetes, there is a lack of systematic reviews that specifically assess the impact of resistance training on the quality of life in adults aged 18 years and older with diabetes. This gap in the literature highlights the need for a comprehensive study to evaluate how various strength training programs affect the quality of life in this population.

1.2 Problem Statement

Proper medication, a balanced diet, and adequate workouts are widely recommended to help control Type 2 diabetes. However, understanding the right methods for ensuring sustainability of the above has been a challenge. In this research, the problem pertained to the adaptability of strength training programs by Type 2 Diabetes patients to improve their quality of life. The research, therefore, focused on understanding the components of quality of life and integrating them into strength training programs that could be used by Type 2 Diabetes individuals to ensure improved health outcomes. Existing literature does not provide sufficient clarity on the type of strength training programs and their implications for Type 2 Diabetes, which this research aimed to address.

1.3 Research Question

What is the comparative impact of structured vs. unstructured strength training programmes on quality of life in adults with Type 2 Diabetes?

1.4 Aims and Objectives

This systematic review aimed to analyse the existing literature to establish the effectiveness of different strength training programs on the quality of life in Type 2 Diabetes adults, aged 18 and older.

1.5 Objectives of the Study

In this study, the research objectives were as follows:

- To identify and describe different strength training programs (structured and unstructured) for patients with T2DM.
- To evaluate the effectiveness of each strength training program for patients with T2DM patients.
- To recommend effective strategies for patients with T2DM to adhere to strength training programs for a better quality of life.

1.6 Significance of the Study

Although physical activity is widely acknowledged as beneficial for individuals with Type 2 diabetes, there remains limited clarity regarding the specific contribution of structured strength training programs to quality-of-life outcomes. Community-based initiatives, such as the “Lift for Life” program in Australia (Teychenne et al., 2015), have demonstrated improvements in glycemic control and overall well-being for individuals with or at risk of diabetes. However, despite these promising results, few studies have systematically evaluated the broader impact of strength training on quality of life in adults with Type 2 diabetes.

This study addresses this gap by synthesizing current evidence on the effectiveness of strength training interventions for this population. By focusing explicitly on quality of life outcomes, the study provides novel insights that extend beyond traditional measures such as glycemic control and cardiovascular fitness. The findings contribute to the existing body of knowledge by clarifying the role of strength training in diabetes management and offering a stronger evidence base for its integration into clinical practice.

The practical implications are significant. The results are expected to inform clinical guidelines, intervention strategies, and community-based programs aimed at improving long-term health outcomes in adults with Type 2 diabetes. Furthermore, the study highlights the potential of strength training as a cost-effective, sustainable, and scalable approach to enhancing both physical and psychosocial well-being, thereby supporting patients, practitioners, and policymakers in the development of comprehensive diabetes care strategies.

1.7 Outline of this Research Report/ Dissertation / Thesis

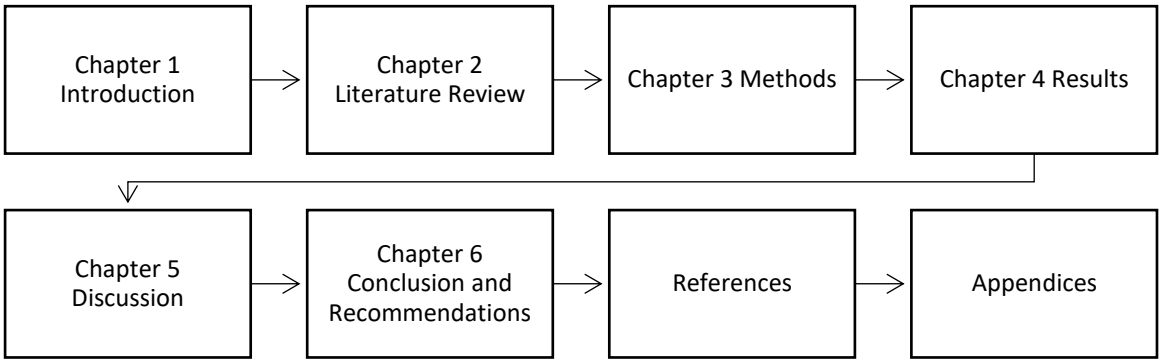


Figure 1-1 Outline of the thesis

This dissertation is structured into six chapters, supported by references and appendices, to provide a comprehensive exploration of the effectiveness of strength training programs on the quality of life in adults with Type 2 Diabetes Mellitus (T2DM).

Chapter 1: Introduction presents the background and context of the study, highlighting the burden of T2DM and its impact on quality of life. It outlines the research problem, objectives, and significance of the study, and concludes with the structural overview of the dissertation.

Chapter 2: Literature Review provides a critical synthesis of existing studies on T2DM, quality of life, and the role of physical activity, with a particular emphasis on strength training interventions. This chapter identifies key knowledge gaps and establishes the theoretical and empirical foundation for the current study.

Chapter 3: Methods describes the systematic review methodology employed. It details the inclusion and exclusion criteria, databases searched, data extraction process, and critical appraisal tools, ensuring transparency and replicability.

Chapter 4: Results present the findings of the systematic review, including a summary of the studies identified, their methodological quality, and the impact of structured and unstructured strength training programs on clinical and quality of life outcomes.

Chapter 5: Discussion interprets the results in relation to the existing body of literature. It explores the implications of the findings for clinical practice, patient engagement, and long-term disease management, while also addressing the study's limitations.

Chapter 6: Conclusion and Recommendations summarise the major findings, highlighting the contribution of the study to diabetes management strategies. It provides practical recommendations for healthcare professionals and policymakers, as well as directions for future research.

The References section lists all scholarly sources cited in the dissertation, formatted according to APA 7th edition guidelines. The Appendices provide supplementary material, including screening tools, data extraction forms, and additional supporting documents.

Chapter 2 Literature Review

2.1 Introduction

The global rise in Type 2 Diabetes Mellitus (T2DM) underscores the urgent need for effective interventions to improve not only clinical outcomes but also the overall quality of life (QoL) of affected individuals. T2DM is associated with persistent hyperglycaemia, insulin resistance, and progressive β-cell dysfunction, which collectively contribute to long-term complications that impair physical, psychological, and social well-being. Beyond its metabolic burden, T2DM significantly reduces QoL due to fatigue, mobility limitations, diabetes distress, and reduced independence.

Among lifestyle-based interventions, strength training has emerged as a promising strategy for managing T2DM. Evidence demonstrates that resistance-based exercise improves insulin sensitivity, muscle mass, and glycaemic control, thereby reducing the risk of complications. However, while the physiological benefits of strength training are well established, its broader influence on QoL outcomes remains less clear. Importantly, different approaches to strength training, structured programs (supervised, goal-directed, and protocol-driven) versus unstructured programs (self-directed and lifestyle-integrated) may differ in their impact on adherence, sustainability, and QoL.

This literature review critically examines current evidence on the relationship between strength training and QoL in adults with T2DM. It specifically compares structured and unstructured resistance training interventions, evaluates their effects on physical, psychological, and social domains of QoL, and identifies adherence-related factors that influence long-term outcomes. By synthesising existing systematic reviews and meta-analyses, this chapter highlights strengths, limitations, and gaps in the literature, providing the foundation for the present systematic review.

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterised by persistent hyperglycaemia, arising from a combination of insulin resistance in peripheral tissues (muscle, liver, and adipose tissue) and progressive β-cell dysfunction (Zimmet et al., 2016; ADA, 2023). In the early stages, compensatory

hyperinsulinaemia may temporarily maintain glucose homeostasis, but over time, β-cell exhaustion leads to impaired insulin secretion and chronic hyperglycaemia.

Pathophysiological changes in T2DM include:

- Reduced glucose uptake in skeletal muscle, which accounts for the majority of insulin-mediated glucose disposal.
- Increased hepatic glucose production, contributing to fasting hyperglycaemia.
- Adipose tissue dysfunction, which elevates free fatty acids and inflammatory cytokines (e.g., TNF-α, IL-6), further exacerbating insulin resistance (Kahn et al., 2006).
- Oxidative stress and systemic inflammation, which accelerate microvascular (neuropathy, retinopathy, nephropathy) and macrovascular (cardiovascular disease) complications.

Obesity, particularly central adiposity, is a major contributor to insulin resistance, as visceral fat promotes lipotoxicity, chronic inflammation, and metabolic dysfunction (Longo, et al., 2019). Inactivity and poor lifestyle behaviours amplify these effects, reducing insulin sensitivity and accelerating the progression of T2DM.
Understanding these mechanisms provides a strong rationale for exercise-based interventions. Since skeletal muscle is central to glucose uptake and metabolic control, strength training directly targets a key pathophysiological deficit in T2DM by improving muscle mass, enhancing insulin sensitivity, and reducing inflammatory markers. This makes resistance exercise particularly relevant for both clinical outcomes and quality of life.

Strength training has been identified as a highly effective non-pharmacological intervention for the management of T2DM. Unlike aerobic exercise, which primarily improves cardiorespiratory function, strength training specifically targets skeletal muscle. The primary site of insulin-mediated glucose disposal. By increasing muscle mass and enhancing insulin sensitivity, resistance training directly addresses a core pathophysiological deficit in T2DM (Colberg et al., 2016; Ivy, 2020).

Physiological Benefits

Evidence from systematic reviews and clinical trials demonstrates that strength training:

- Enhances glucose uptake via GLUT-4 translocation in skeletal muscle, promoting insulin-independent glucose disposal (Colberg et al., 2016).
- Reduces HbA1c and fasting glucose, reflecting improved long-term glycaemic control (Sigal et al., 2006; Longo et al., 2019).
- Decreases visceral and central adiposity, which are strongly linked to insulin resistance and cardiometabolic complications (Longo et al., 2019).
- Improves body composition, with gains in lean muscle mass that enhance strength, mobility, and independence.

These physiological adaptations are essential not only for disease management but also for improving functional ability and daily living, which directly contribute to QoL.

Quality of Life in patients with T2DM

Quality of life (QoL) is a multidimensional construct that reflects an individual's overall well-being across physical, psychological, and social domains. For people with T2DM, QoL is often impaired due to the combined burden of metabolic dysregulation, lifestyle restrictions, and complications such as neuropathy, cardiovascular disease, and chronic fatigue (Rubin & Peyrot, 1999). The daily demands of self-monitoring, dietary restrictions, and medication adherence also contribute to diabetes-related distress, further reducing QoL (Hernández-Tejada et al., 2012).

Domains of QoL

- Physical health: mobility, pain, functional capacity, and independence in daily activities.
- Psychological well-being: mood, self-esteem, anxiety, and diabetes-related distress.
- Social functioning: interpersonal relationships, role fulfilment, and community participation.

Impairments across these domains are interrelated: for example, limited physical capacity may reduce independence, which in turn undermines psychological well-being and social participation.

Measurement of QoL

A range of validated tools are commonly used to assess QoL in patients with T2DM, including:

- SF-36 (Short Form-36 Health Survey) – measures physical and mental health domains.
- WHOQOL-BREF – evaluates physical, psychological, social, and environmental domains.
- Diabetes Quality of Life (DQOL) scale – focuses on diabetes-specific concerns such as treatment satisfaction, worry, and disease burden.

Although these instruments are widely applied, methodological inconsistencies exist across studies. Different tools emphasise different domains, making cross-study comparisons challenging. Moreover, not all studies employ diabetes-specific QoL measures, potentially underestimating the impact of interventions such as strength training.

While improvements in metabolic outcomes are well established, the evidence regarding QoL is less consistent. Some studies show that strength training reduces fatigue, improves mobility, and enhances self-efficacy, leading to better physical and psychological QoL (Mager et al., 2021). Others, however, report minimal or no significant changes in psychosocial outcomes such as mood, anxiety, or social participation (Myers et al., 2013). The heterogeneity of findings may be due to differences in program design, intervention duration, and the QoL instruments used.
Strength training has the potential to improve QoL by enhancing functional capacity, self-efficacy, and independence. Meta-analyses have reported modest but meaningful improvements in physical functioning and fatigue reduction, which translate into greater participation in daily life (Mager et al., 2021). However, improvements in psychological and social domains are less consistently observed (Myers et al., 2013). This variation highlights the need for further synthesis to clarify which dimensions of QoL are most responsive to resistance training interventions.

The pathways through which strength training may influence QoL in individuals with T2DM are both physiological and psychosocial. Understanding these mechanisms provides insight into why resistance training can be effective, while also explaining inconsistencies in the literature.

Physiological Mechanisms

- Improved glycaemic control: Strength training enhances glucose uptake through GLUT-4 translocation, reduces HbA1c, and improves insulin sensitivity (Colberg et al., 2016). Better metabolic stability reduces fatigue and complications, contributing to greater independence in daily activities.
- Increased muscle mass and strength: Gains in lean body mass improve mobility, balance, and functional capacity, reducing the risk of falls and promoting autonomy (Ivy, 2020).
- Reduced adiposity and systemic inflammation: Decreased visceral fat and lower inflammatory markers (e.g., TNF-α, IL-6) contribute to improved energy levels and reduced comorbidity burden (Dela et al., 2019).

Psychological Mechanisms

- Enhanced mood and reduced distress: Resistance exercise stimulates endorphin release and has been linked to lower rates of depression and anxiety in people with chronic diseases (Stonerock et al., 2015).
- Improved self-efficacy: Mastery of exercise tasks and progressive overload build confidence, which may reduce diabetes-related distress and improve coping.
- Behavioural empowerment: Participation in structured exercise can improve adherence to other self-management behaviours, such as healthy eating and regular glucose monitoring. (Miller & DiMatteo, 2013).

Social and Behavioural Mechanisms

- Structured programs: Provide supervision, social support, and accountability, which may enhance motivation and adherence. (Miller & DiMatteo, 2013).
- Unstructured lifestyle-based activity: While less intensive, it integrates movement into daily life and may improve sustainability by reducing cost, accessibility, and time barriers (Abusleme-Allimant et al., 2023).
- Community and peer support: Group-based strength programs often foster social interaction, which can improve emotional well-being and reduce isolation. (Sherifali et al., 2024).

Limitations of Current Evidence

Despite these plausible mechanisms, systematic reviews rarely measure all three QoL dimensions together. Many studies rely on physiological endpoints (HbA1c, muscle

mass) and neglect psychosocial domains. As a result, the evidence base remains fragmented, with little clarity on whether strength training consistently improves psychological or social aspects of QoL.

Impact on Quality of Life

While improvements in metabolic outcomes are well established, the evidence regarding QoL is less consistent. Some studies show that strength training reduces fatigue, improves mobility, and enhances self-efficacy, leading to better physical and psychological QoL (Mager et al., 2021). Others, however, report minimal or no significant changes in psychosocial outcomes such as mood, anxiety, or social participation (Stonerock et al., 2015). The heterogeneity of findings may be due to differences in program design, intervention duration, and the QoL instruments used.

2.2 Structured and Unstructured Strength Training Programs

Structured and unstructured strength training programs are two broad categories commonly used in managing Type 2 Diabetes Mellitus (T2DM) in patients. Structured strength training involves specific, planned exercises performed at set times, often under supervision, aimed at improving muscle mass, insulin sensitivity, and metabolic control. Examples of structured training include resistance exercises with weights, circuit training, and progressive overload programs, which have been shown to significantly improve health outcomes in individuals with diabetes (Gordon et al., 2009). On the other hand, unstructured strength training is more flexible and tailored to an individual's lifestyle and preferences, including activities such as carrying groceries, climbing stairs, or engaging in physical hobbies like gardening. While less regimented, unstructured strength training still offers considerable health benefits by improving muscle strength and enhancing glucose metabolism in diabetic patients (Sigal et al., 2006).

Strength training exercises play a crucial role in improving the overall health and quality of life of diabetic patients by enhancing muscle strength, metabolic efficiency, and functional mobility. Squats are a well-known exercise that targets multiple muscle groups, mainly in the lower body. This is a compound movement and is beneficial for

diabetic patients as it burns a high number of calories due to its high energy demand. It uses a significant amount of glycogen (Garneau et al., 2023). This exercise not only improves strength but also improves flexibility and balance that are key benefits for diabetic patients, particularly those with neuropathy who are at higher risk of falls and injuries.

Another important exercise for strengthening the lower body is walking lunges. It targets mainly the gluteus muscles and quadriceps muscle. These exercises help enhance mobility and increase calorie expenditure, which is important for weight management and muscle strengthening. Way et al. (2023) highlighted that walking lunges are particularly beneficial for diabetic patients by improving stability, which is crucial for those with diabetic neuropathy. However, the risk of numbness in the feet during these exercises may pose a challenge for some patients, leading to discontinuation in training programs.

Push-ups target multiple upper body muscles, including the chest, shoulders, and triceps. Jia et al. (2024) stated that push-ups are effective in building muscle mass and reducing body fat. Regular push-ups help improve overall strength and reduce the risk of injury that is caused by weakened muscles. Canli and Aldhahi. (2024) suggest that strength improvements from push-ups help diabetic patients prevent complications which are related to muscle weakness and poor posture.

Pull-ups, which primarily target the upper back and arms, can be a challenging exercise for many individuals. However, the benefits in strengthening back muscles and improving posture are significant. According to Veiga et al. (2024) Latissimus dorsi pull-down machines provide a viable alternative to pull-ups, offering similar benefits. This exercise is helpful for diabetic patients who suffer from nerve damage, as improved posture reduces pain and discomfort.

Structured resistance programs which characterised by supervision, progression principles, and adherence monitoring, tend to produce greater physiological improvements and may enhance patient confidence and safety (Boulé et al., 2017).

However, unstructured programs, where individuals incorporate strength-based activities into daily routines, may improve long-term adherence by reducing barriers such as cost, accessibility, and time (Abusleme-Allimant et al., 2023). To date, few reviews have directly compared these two approaches, particularly in relation to QoL outcomes, highlighting a critical gap in the literature.

2.3 Critical Implication of Training Programs on Type 2 Diabetic Patients

Exercise has a twofold effect on Type 2 Diabetes patients; it can improve both metabolic and mental health while also posing a risk of physical injuries if not performed correctly. Regular strength training enhances insulin sensitivity, reduces HbA1c levels, and promotes cardiovascular health, making it an essential component of diabetes management Colberg et al. (2016). Additionally, strength training has been shown to improve psychological well-being by reducing stress and depressive symptoms commonly associated with diabetes (Balducci et al., 2012). However, performing this exercise incorrectly, using excessive load, or inadequate supervision can increase the risk of musculoskeletal injuries, particularly in older adults with diabetes-related complications such as neuropathy or retinopathy (Sigal et al., 2006). The effectiveness of strength training programs depends on several factors, including the type of exercise, the patient's baseline physical condition, and their adherence to the program (Bird & Hawley, 2017). A well-structured training program, supervised by healthcare professionals, ensures safety while maximizing health benefits.

For individuals with T2DM, exercise prescription must account for the diabetes-related complications that may influence safety, adherence, and outcomes. Physiotherapists play a critical role in adapting strength training programs to accommodate these challenges while maximising benefits for quality of life.

Neuropathy

Peripheral neuropathy reduces sensation in the feet and lower limbs, increasing the risk of falls, ulcers, and balance deficits. Strength training programs must therefore:

- Emphasise balance and proprioceptive training alongside resistance exercises.
- Avoid barefoot activities; supportive footwear and protective foot care are essential.
- Progress load gradually to reduce the risk of musculoskeletal injury.

Retinopathy

Diabetic retinopathy may be aggravated by high intraocular pressure associated with heavy lifting or Valsalva manoeuvres. For these patients:

- High-intensity or maximal resistance training should be avoided.
- Exercises should be performed in a controlled manner with proper breathing techniques.
- Supervision is critical to ensure safe lifting strategies.

Nephropathy and Hypertension

Individuals with nephropathy or hypertension require careful monitoring during resistance training, as high-intensity exercise may exacerbate blood pressure fluctuations. Physiotherapists should:

- Prescribe moderate-intensity training, avoiding very heavy loads.
- Monitor cardiovascular responses, ensuring safe progression.
- Integrate aerobic conditioning where appropriate for cardiovascular support.

Musculoskeletal Comorbidities

Obesity and degenerative joint disease are common in T2DM and may limit exercise capacity. Modifications such as resistance bands, pneumatic equipment (e.g., HUR), and aquatic therapy may improve accessibility and reduce joint loading.

Addressing these clinical considerations ensures that strength training interventions are not only effective but also safe, accessible, and sustainable. Tailoring programs to individual limitations promotes adherence, reduces the risk of adverse events, and enhances both functional outcomes and quality of life. Despite this, most systematic reviews give little attention to physiotherapy-specific adaptations, limiting their applicability to clinical practice.

Training Program Variations

The choice of training program varies based on the patient's physical status and medical needs. For example, individuals with obesity and Type 2 diabetes may require a different approach compared to those who are underweight. Ishiguro et al. (2015) conducted a systematic review and meta-analysis to identify the characteristics of resistance training (RT) programs that maximize glycemic control in patients with Type 2 diabetes mellitus (T2DM). They analysed data from various studies to assess how different RT protocols influenced glycosylated haemoglobin (HbA1c) levels. Hba1c is a key marker of long-term blood glucose control. Their analysis revealed that RT programs with a higher number of sets per exercise session (≥21 sets) were more effective in reducing HbA1c levels. Additionally, patients with a shorter duration of diabetes (<6 years) or higher baseline HbA1c levels (≥7.5%) experienced more significant improvements. On the contrary, the effect was limited in studies of patients with a particularly high baseline body mass index (BMI) (≥32 kg/m²). Based on these findings, the authors recommended that RT programs be tailored to individual patient characteristics, such as diabetes duration, baseline HbA1c levels, and BMI, to optimize glycemic control. Ishiguro et al. (2015) established that no single exercise program is universally effective for all diabetic patients. Instead, individualized approaches tailored to each patient's condition, mental health, and physical ability are essential.

Exercise Continuity and Diet

The effectiveness of strength training programs in improving the quality of life for adults with Type 2 diabetes is influenced by multiple lifestyle factors, particularly exercise continuity, diet, and the management of stress.

An important challenge in diabetic care is ensuring consistent adherence to structured exercise programs, as the discontinuity of these exercises can limit the benefits of strength training. Cai et al. (2023) examines the importance of combining physical exercise with dietary control for achieving optimal results in diabetic patients. They focus on the long-term benefits of sustained exercise programs, which are highly dependent on patient adherence. Their findings highlight that when patients are consistently engaged in exercise routines and adhere to it, it directly impacts the success of managing blood glucose levels and improving overall quality of life.

While their study does not specifically isolate adherence as the central focus, they do note that for effective outcomes, individuals need to maintain regular participation in

both exercise and diet interventions. This implies that adherence to strength training programs is crucial for the improvements in health and quality of life for diabetic individuals.

As highlighted by Cai et al. (2016), regular exercise significantly reduces HbA1c levels in diabetic patients aged 18-45, with the greatest effects observed when combined with dietary modifications.
However, adherence is often compromised by sedentary behaviours, poor eating habits, time constraints, and the risk of exercise-induced injuries. Kemps et al. (2019); Qiu et al. (2018).

Kemps et al. (2021) conducted a study to assess the long-term effects of a structured exercise program, specifically focusing on the impact of resistance training on insulin sensitivity, glucose metabolism, and the quality of life of individuals with Type 2 Diabetes Mellitus (T2DM). They aimed to investigate the barriers and facilitators to adherence in a 12-week resistance training program. Kemps et al. (2021) provide evidence that while adherence is often a challenge in resistance training programs for diabetic patients, when participants adhere to the program, significant improvements in health outcomes can occur. The study highlights that addressing barriers to adherence is essential for the success of exercise interventions for individuals with T2DM.

Qiu et al. (2022) focused on a strength training program designed for diabetic patients, analysing its effects on both physical and psychological health outcomes. The study aimed to assess how different types of interventions e.g. supervised versus unsupervised exercise programs affected adherence and outcomes. Their findings emphasize the importance of supervision, motivation, and psychological support in promoting adherence to exercise programs. Their study suggests that individualized support and addressing psychological barriers can improve adherence and enhance the effectiveness of strength training interventions for diabetes management.

These studies have emphasized the challenges related to adherence in strength training programs for diabetic patients. Kemps et al. (2021) found that while adherence was often hampered by barriers such as time constraints and fear of injury, participants who were able to maintain participation showed significant improvements in insulin

sensitivity and quality of life. Similarly, Qui et al. (2022) emphasized the role of supervision, social support, and psychological factors in promoting adherence to strength training programs. Together, these studies suggest that addressing both physical and psychological barriers to adherence is crucial for optimizing the benefits of strength training for diabetic patients.

Beyond adherence, dietary habits and stress levels critically modulate the metabolic benefits of strength training. Barreira et al. (2018) found that excessive sugar intake can diminish the positive effects of resistance training on glycemic control, suggesting that dietary regulation is necessary for optimizing exercise outcomes.

Dabaghi et al. (2020) emphasized the role of psychological stress, which can lead to overeating and smoking, both of which negatively impact blood glucose regulation and cardiovascular health. Chronic stress has been shown to increase cortisol levels, which can counteract the insulin-sensitizing effects of strength training.

The interplay between these factors shows the need for a holistic, multidisciplinary approach in designing strength training interventions for Type 2 diabetic patients. While strength training has well-documented physiological benefits, its impact on quality of life is maximized when paired with sustainable behavioural modifications. These adherence strategies include, stress management, and dietary adjustments. This systematic review aims to assess the role of strength training in improving the quality of life in adults with diabetes by considering these interconnected influences, ensuring that training programs are not only effective but also practical and sustainable.

2.4 Factors Influencing the Quality of Life in Type 2 Diabetic Patients

Quality of life (QoL) is a multidimensional concept encompassing physical, psychological, and social well-being. With regards to T2DM, QoL is particularly important because the disease and its management can profoundly impact daily living, emotional health, and overall satisfaction with life. For adults with T2DM, quality of life is often decreased by complications associated with the disease, such as neuropathy, retinopathy, and cardiovascular issues, alongside the psychological burdens of managing a chronic condition (Schmidt et al., 2018).

Strength training programs have developed as an essential component of diabetes management, offering benefits that extend beyond glycemic control. Research has demonstrated that these programs can enhance physical fitness, improve body composition, and foster a sense of accomplishment and empowerment among participants (Tao et al., 2019). As such, strength training can contribute to improving the quality of life for T2DM patients.

Several factors contribute to improving the quality of life for patients with T2DM, particularly when they are undergoing strength training programs. These factors include family support, physical activity, proper nutrition, avoiding smoking, managing stress, and maintaining a healthy weight.

Family Support

Family members can support a patient with Type 2 diabetes in leading a healthy lifestyle by creating a meal plan and reminding them about their importance and regular medication. The research conducted by Bellou et al. (2018) is a systematic review that examines the role of family support in diabetes management, particularly for patients with Type 2 diabetes. The research offers evidence-based insights into how family involvement can positively affect diabetes management, such as through regular blood glucose monitoring and encouragement of physical activity. However, the quality of the studies included in the review may vary, leading to potential biases in the results. Some studies might have small sample sizes so the findings may not be generalizable to all populations, as the studies included in the review may focus on specific demographic groups or cultural contexts that do not represent the broader population of diabetic patients. Currently, many individuals are consuming sugar containing energy drinks or beverages, oily and spicy foods. Therefore, it is important for family members to take steps to discourage Type 2 diabetic patients from consuming these foods, as they are known to contribute to the risk of diabetes.

One of the first steps is education and understanding of the condition. Family members should educate themselves about Type 2 diabetes, its symptoms, and management strategies. This knowledge equips them to provide informed support and helps reduce the feeling of isolation often experienced by patients (Cai, Liu, & Wang, 2024). Participating in diabetes education sessions or workshops alongside the patient is also

beneficial in learning about nutrition, exercise, and blood glucose monitoring (American Diabetes Association, 2023).

In meal planning and preparation, families should collaborate with the patient to create balanced meal plans, including whole grains, lean proteins, healthy fats, and vegetables, while carefully managing carbohydrate intake (Sigal et al., 2006). Cooking together promotes healthier eating habits and encourages the patient to take responsibility for their dietary choices (Cai et al., 2024).

Encouragement and motivation are crucial aspects of family support. Family members can encourage patients to regularly monitor their blood glucose levels and participate in physical activities together, such as walking, biking, or attending fitness classes. This makes exercise more enjoyable and reduces the reluctance to engage in physical activity (Way, Gray, & Jenkins, 2023). In addition, providing emotional support through active listening and open communication fosters trust and helps address concerns regarding diabetes management (American Diabetes Association, 2023). Celebrating milestones, such as achieving target blood glucose levels or adhering to a workout routine, helps reinforce positive behaviours and boosts morale (Sigal et al., 2006).

In monitoring health behaviours, family members can help patients track their food intake and remind them to take medications as prescribed. This ensures better adherence to treatment plans and reduces the chances of forgetting essential medication (Cai et al., 2024). Stress management is another important factor, as stress can negatively impact blood sugar levels. Family members can encourage activities such as yoga, meditation, or engaging in hobbies to reduce stress and provide comfort during challenging times (American Diabetes Association, 2023).

Finally, families can seek professional help by collaborating with the patient's healthcare team, including dietitians, diabetes educators, and therapists, for a comprehensive approach to diabetes management. Participating in support groups for families of diabetic patients can also offer valuable insights and allow them to share experiences with others facing similar challenges (Sigal et al., 2006). By actively engaging in these steps, family members can significantly enhance the diabetes management process, improve adherence, and create a supportive environment that encourages a healthier lifestyle for diabetic patients.

Physical Exercise

Physical exercise is also considered a key factor in helping individuals with Type 2 diabetes lead a better quality of life by effectively managing the condition. In the systematic review by Galaviz et al. (2019), physical activity, particularly aerobic and resistance exercise, is highlighted as a key factor in improving insulin sensitivity in individuals with Type 2 diabetes. Regular exercise has been shown to enhance the translocation of GLUT4 (glucose transporter type 4) to the cell membrane in skeletal muscle, which increases glucose uptake independently of insulin, reducing the need for exogenous insulin (Galaviz et al., 2019). Additionally, physical activity promotes muscle adaptation, increasing muscle mass, which provides a larger reservoir for glucose uptake and, thereby, improves insulin sensitivity (Galaviz et al., 2019).
Furthermore, exercise reduces systemic inflammation, a major contributor to insulin resistance, by lowering inflammatory cytokines (Galaviz et al., 2019). This reduction in inflammation improves the function of insulin and facilitates better glucose metabolism. Additionally, the authors suggest that exercise improves metabolic flexibility, meaning the body's ability to switch efficiently between different fuel sources, such as glucose and fatty acids, which is crucial for managing blood glucose levels and restoring proper insulin function (Galaviz et al., 2019).

These mechanisms underscore the importance of physical activity in managing Type 2 diabetes and improving insulin sensitivity, which ultimately contributes to better glucose control and quality of life for diabetic patients.

Exercise can support men in keeping a waist circumference within 40 inches and women in keeping this circumference within 35 inches because above these levels are highly associated with an increased risk of Type 2 diabetes. Reviewing the literature by Carbone et al. (2019), it is also identified that physical exercise is a key factor in helping patients of Type 2 diabetes to lead a quality life by helping body cells use available insulin to take glucose from the blood, increasing insulin sensitivity and supports muscle cells to take glucose during unavailability of insulin.

It has been found that physical inactivity is responsible for low cardiovascular fitness and elevated blood glucose levels. Additionally, the authors suggest that individualized exercise regimens, tailored to a patient’s specific capabilities and preferences, are essential for ensuring long-term adherence to physical activity

programs. Such personalized approaches can significantly enhance the quality of life for diabetic patients by supporting better glycemic control, promoting weight management, and reducing the risk of other diabetes-related complications Carbone et al., (2019).

The World Health Organization (WHO) provides key guidelines for managing Type 2 diabetes through physical activity. These include engaging in at least 150 minutes of moderate-intensity aerobic activity per week, with a goal of 300 minutes for additional benefits. Resistance training, performed on two or more days weekly, helps improve muscle mass and insulin sensitivity. Flexibility and balance exercises, like yoga, are recommended to enhance mobility and reduce fall risks, especially in older adults. The WHO also emphasizes reducing sedentary behaviour and adopting individualized physical activity plans to improve glycemic control and support overall health in diabetes management.

Zhang et al. (2019) explains that patients with Type 2 diabetes can perform moderate-intensity physical exercises, including cycling, dancing, swimming, mowing the lawn, walking briskly, and playing sports to lead a quality life. Regular aerobic exercise helps to lead a quality life by reducing cardiovascular risk in people with diabetes, resistance exercise increases muscle mass and strength, and stretching exercise increases flexibility and range of motion while maintaining a healthy lifestyle by managing Type 2 diabetes (Lascar et al., 2018).

In understanding the multifaceted impact of exercise on Type 2 diabetes management and quality of life, a diagram adapted from Yang et al. (2019) effectively illustrates how physical activity influences various organs and metabolic processes. This diagram places exercise at the centre, highlighting its effects on key systems: the pancreas, muscles, adipose tissue, circulatory system, and liver. The diagram provides a visual representation of how exercise leads to improved insulin sensitivity, glucose metabolism, fat reduction, and overall metabolic health, which together contribute to enhanced quality of life for individuals with Type 2 diabetes.

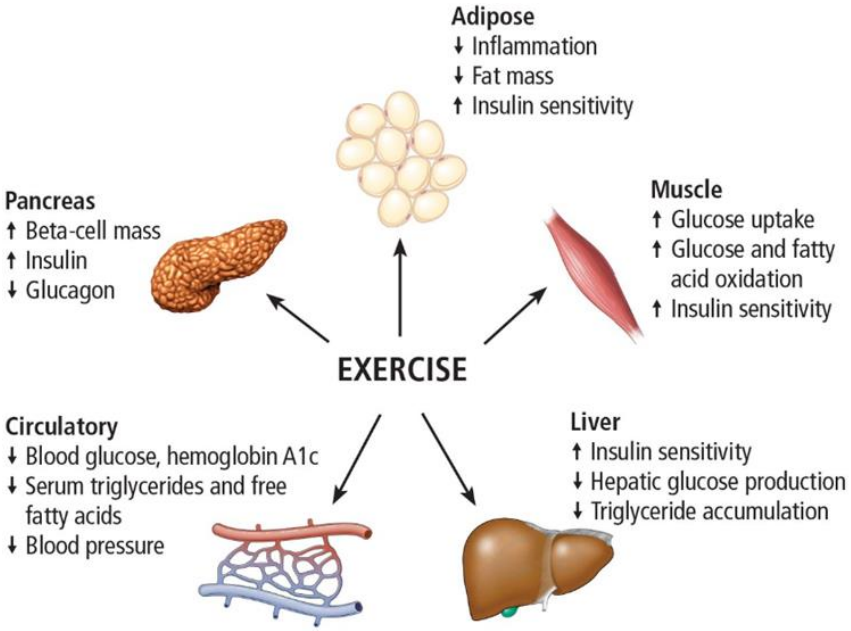


Figure 2-1 Benefits of exercise in managing Type 2 diabetes to lead a quality life

(Source: Yang *et al.,* 2019)

Nutrition

The importance of nutrition in controlling Type 2 diabetes and enhancing quality of life has been shown in numerous research. Glycaemic management and blood lipid profiles, for instance, are greatly enhanced by a healthy, balanced diet that emphasises whole grains, brown rice, oats, fresh fruits and vegetables, unsalted almonds, and low-fat milk Park et al. (2019). Evert et al. (2019) offered evidence that personalised nutrition therapy that emphasises portion control and carbohydrate quality can improve glycaemic outcomes and aid in weight management. Additionally, Goldenberg et al. (2017) carried out a systematic review and meta-analysis showing that diets high in fibre, which are characterised by a low glycaemic index and a lower intake of refined sugar, are helpful in improving insulin sensitivity and lowering HbA1c levels. When taken as a whole, these studies highlight the importance of dietary treatments that prioritise whole, unprocessed foods and high fibre intake in the management of Type 2 diabetes since they directly improve metabolic control and overall quality of life.

Avoid smoking

One of the most important modifiable aspects of managing Type 2 diabetes is quitting smoking, which is linked to significant gains in glycaemic control and general quality of

life. Quitting smoking can lower the risk of Type 2 diabetes by 30% to 40%, lower the incidence of complications from the condition, and promote improved disease management, according to the World Health Organisation (2024). Epidemiological research backs up this assertion. For example, a meta-analysis by Pan et al. (2015) showed that current smokers are far more likely to develop Type 2 diabetes than non-smokers, indicating that quitting smoking may have protective benefits.

The Centres for Disease Control and Prevention (CDC, 2022) and other observational studies have also shown that quitting smoking can improve metabolic parameters in diabetic patients. However, the magnitude of these benefits frequently varies depending on the length of time abstinence is maintained and the health characteristics of the individual. Incorporating smoking cessation programs into all-encompassing diabetes treatment strategies will also improve glycaemic control and lower cardiovascular risks, which will improve quality of life, according to interventional studies (Smith et al., 2017). Smoking avoidance is crucial for reducing the risk and complications of Type 2 diabetes, as evidenced by the overall body of evidence from longitudinal and interventional studies, even though some cross-sectional studies only find weak links between quitting smoking and glycaemic improvement.

Managing Stress and Anxiety

Stress and anxiety are key psychological factors that significantly influence an individual's ability to manage Type 2 diabetes, impacting glycemic control and overall quality of life. Yang et al. (2019) highlight that engaging in relaxing activities such as walking in nature, reading, listening to music, or playing sports can markedly reduce stress levels in diabetic patients. This reduction in stress is critical for diabetes care because chronic stress triggers the excessive release of cortisol and adrenaline, which in turn elevates blood glucose levels and exacerbates insulin resistance.

Several studies support the beneficial role of stress management in diabetes outcomes. For instance, Surwit et al. (2002) conducted a randomized controlled trial (RCT) demonstrating that stress reduction interventions, including cognitive-behavioural therapy (CBT) and relaxation techniques, led to significant improvements in glycemic control. Similarly, van Son et al. (2013) found that mindfulness-based stress reduction (MBSR) programs resulted in lower haemoglobin A1c (HbA1c) levels,

thereby linking improved psychological well-being to better metabolic outcomes. In contrast, Hackett and Steptoe (2017) noted that while stress management programs show short-term improvements in emotional well-being, their long-term effects on blood glucose regulation remain inconsistent, highlighting the need for sustained psychological interventions. Moreover, Naicker et al. (2018) emphasized the importance of personalized stress management strategies, as individuals respond differently to stress-reducing activities based on lifestyle, personality, and cultural background.

A notable strength across this body of research is the growing acknowledgment of the role of psychological factors in diabetes care, which has led to the integration of stress management programs in clinical settings. Studies such as those by Yang et al. (2019) and Surwit et al. (2002) offer robust evidence supporting the immediate benefits of behavioural interventions. However, gaps remain in the literature, particularly regarding the long-term sustainability of these benefits. Many studies have relatively short follow-up periods, making it challenging to assess whether stress reduction techniques provide lasting improvements in glycemic control. Additionally, while several interventions focus on individual strategies, social and environmental stressors (e.g. financial pressures or lack of family support) are often underexplored. Future research should aim to conduct longitudinal studies and implement multi-faceted interventions that address both psychological and social determinants to further strengthen the evidence base.

Managing body weight

Managing body weight is a critical factor in the prevention and management of T2DM, as excess adiposity, particularly visceral fat, plays a central role in the development of insulin resistance and subsequent metabolic dysfunction. Obesity predisposes individuals to T2DM through several interrelated mechanisms. For instance, excess adipose tissue releases high levels of free fatty acids and pro-inflammatory cytokines (e.g., TNF-α, IL-6), which interfere with insulin signalling pathways in key metabolic tissues such as the liver and skeletal muscle (Kahn, Hull, & Utzschneider, 2006). Moreover, adipose tissue dysfunction alters the secretion of adipokines like leptin and

adiponectin, further impairing glucose regulation and promoting insulin resistance. Ectopic fat deposition in non-adipose tissues, a process known as lipotoxicity, also contributes to reduced insulin sensitivity by disrupting normal cellular function.

Numerous studies underscore the benefits of maintaining a balanced body weight for improving glycemic control and reducing the risk of diabetes-related complications. For example, systematic reviews have shown that weight loss interventions significantly improve insulin sensitivity and lower the incidence of Type 2 diabetes Guh et al. (2009). Large-scale randomized controlled trials, such as the Diabetes Prevention Program (Knowler et al., 2002) and the Finnish Diabetes Prevention Study (Tuomilehto et al., 2001), have demonstrated that lifestyle interventions combining dietary modifications and physical activity lead to sustainable weight loss, enhanced metabolic outcomes, and a reduced risk of progression to diabetes.

These findings collectively highlight that achieving and maintaining a normal body weight is not only beneficial for overall health but is also essential in mitigating the pathophysiological processes that predispose individuals to T2DM. Integrating strategies for weight management into diabetes care is therefore vital for improving long-term health outcomes and quality of life in diabetic patients.

Theoretical Framework

The transtheoretical model of behaviour change offers a comprehensive framework for understanding how individuals progress through distinct stages when adopting new health behaviours, such as incorporating strength training to manage T2DM. In the precontemplation stage, patients often remain unaware of or resistant to the need for change, not recognizing the benefits that regular exercise can offer in terms of glycemic control and overall well-being. As they move into the contemplation stage, as noted by Rahimi et al. (2019), patients begin to recognize that lifestyle modifications, like structured strength training could improve their health outcomes, although they are not yet ready to commit to action. In the planning stage, patients develop specific strategies and set achievable goals to integrate strength training into their daily routine, addressing anticipated barriers and tailoring interventions to their personal

circumstances. Finally, during the action stage, patients actively engage in the prescribed exercise regimen, which has been shown to improve muscle strength, enhance insulin sensitivity, and promote metabolic flexibility, all critical factors for effective diabetes management.

Figure 2.2 illustrates these progressive stages and highlights how interventions based on the transtheoretical model can be optimized to foster sustainable behaviour change and, ultimately, enhance quality of life in diabetic patients (Prochaska & Velicer, 1997) and (Rahimi et al., 2019).

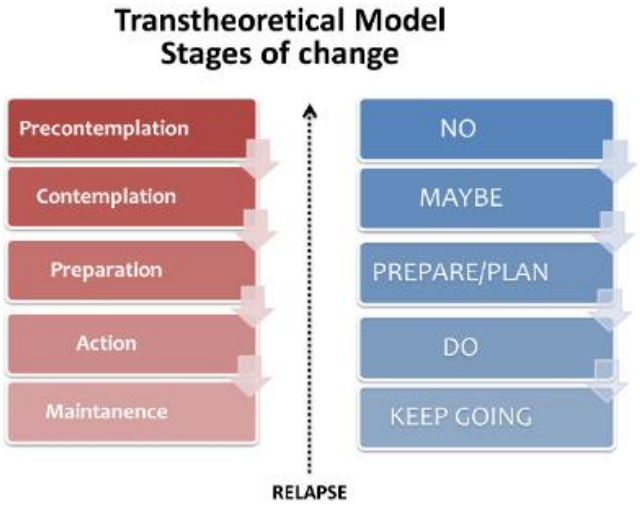


Figure 2-2 Transtheoretical model of health behaviour change

(Source: Rahimi *et al.,* 2019)

Application to Strength Training in T2DM

- Structured programs (e.g., supervised gym-based resistance training) may facilitate progression from preparation to action by providing external accountability, guidance, and safety.
- Unstructured programs (e.g., integrating strength-based activities such as lifting groceries or bodyweight exercises at home) may support the maintenance phase by enhancing accessibility and reducing barriers such as cost or time.
- Physiotherapists can act as “change agents”, identifying a patient’s stage of readiness and tailoring interventions accordingly, for example, motivational interviewing during contemplation, or progressive goal setting during action.

Relevance for Quality of Life

Adherence to strength training is directly linked to sustained improvements in glycaemic control, mobility, and psychosocial well-being. By applying TTM principles, interventions can be better designed to promote long-term adherence, thereby maximising the impact of strength training on all domains of QoL.

2.5 Literature Gap

Despite the growing evidence base supporting exercise as a cornerstone of T2DM management, several critical gaps remain in understanding the role of strength training on quality of life (QoL) outcomes:

Overemphasis on Physiological Outcomes

Most systematic reviews and clinical trials have focused on glycaemic control (HbA1c, fasting glucose) and body composition, while QoL outcomes remain secondary or inconsistently reported (Boulé et al., 2017; Colberg et al., 2016). This narrow focus neglects the holistic impact of strength training on physical, psychological, and social well-being.

Inconsistent QoL Findings

Where QoL outcomes have been assessed, findings are heterogeneous. Some studies demonstrate improvements in physical functioning and fatigue reduction (Mager et al., 2021), whereas others report limited or no significant benefits for psychological or social domains (Stonerock et al., 2018). Variability in measurement tools, program design, and duration makes cross-study comparison difficult.

Lack of Domain-Specific Analysis

Few reviews disaggregate QoL into its specific dimensions (physical, psychological, social). This omission makes it unclear whether strength training primarily benefits functional independence, emotional well-being, or social participation.

Structured vs Unstructured Programs

There is limited comparative evidence on the differential impact of structured (supervised, progressive) versus unstructured (self-directed, lifestyle-integrated) resistance training on QoL. While structured programs may enhance short-term gains and adherence, unstructured approaches may be more sustainable in the long term

(Abusleme-Allimant et al., 2023). This distinction is rarely addressed in systematic reviews.

Physiotherapy-Specific Adaptations

Most reviews overlook clinical considerations relevant to physiotherapists, such as exercise modifications for individuals with neuropathy, retinopathy, or nephropathy. This limits the translational value of existing evidence for clinical practice.

Summary of the Gap

The current literature establishes the physiological benefits of strength training in T2DM but provides insufficient and inconsistent evidence on QoL outcomes, particularly across its multidimensional domains. The role of structured versus unstructured strength training remains unclear, and little guidance exists for physiotherapy-specific adaptations.

2.9 Conclusion

Strength training has been widely recognised as an effective intervention for improving glycaemic control, muscle strength, and body composition in individuals with Type 2 Diabetes Mellitus (T2DM). These physiological benefits provide a compelling rationale for its inclusion in diabetes management. However, its broader impact on quality of life (QoL), a multidimensional construct encompassing physical, psychological, and social well-being remains less clearly defined.

The existing literature is limited by an overemphasis on physiological outcomes, inconsistent findings regarding QoL, and the absence of domain-specific analysis. Furthermore, while structured resistance programs have been studied more extensively, there is little comparative evidence evaluating the effectiveness of structured versus unstructured strength training on QoL outcomes. Importantly, physiotherapy-specific adaptations, which are critical for safe and sustainable implementation in populations with complications such as neuropathy, retinopathy, or nephropathy, are rarely addressed in systematic reviews.

These gaps highlight the need for a focused synthesis of available evidence. By examining the relationship between strength training and QoL in adults with T2DM and by differentiating between structured and unstructured interventions. This study aims

to extend beyond traditional physiological endpoints and provide clinically relevant insights for physiotherapy practice.

Chapter 3 Methodology

3.1 Introduction

This chapter outlines the methodology employed in this systematic review, which adopts a secondary research approach to examine the effectiveness of strength training programs on the quality of life in adults with Type 2 diabetes. The study employs a secondary research approach, drawing on existing empirical data from published studies rather than collecting new primary data.

In research, primary studies involve direct data collection from human participants through methods such as surveys, interviews, or experiments, requiring the identification of sampling techniques, recruitment procedures, and ethical considerations. Conversely, secondary research relies on the analysis of existing empirical data and literature from accessible sources. For this study, secondary data collection was chosen because it is both cost-effective and time efficient. As Tarantino et al. (2024) suggest, primary research may suffer from issues of data validity and reliability when based on human assumptions and experiences, in addition to the increased resource demands for recruitment, data collection, and ethical oversight.

Given the abundant availability of data regarding the effectiveness of strength training programs in managing T2DM and improving quality of life, secondary research provides a robust foundation for addressing the research objectives. This study incorporates a systematic review, a rigorous secondary research method characterized by explicit, transparent, and replicable processes for identifying, selecting, and critically appraising relevant studies. The systematic review methodology enables the synthesis of existing evidence to draw comprehensive conclusions about the impact of strength training on health outcomes in patients with T2DM, as supported by Brandt et al. (2024). This chapter details the rationale behind the chosen methodology and explains the procedures for data collection, appraisal, and synthesis that underpin the systematic review.

By applying this method, the review not only summarizes the evidence on the impact of strength training on quality of life, but also examines adherence related outcome, including supervision, retention rates, and behavioural support strategies, which are recognized as key determinants of long-term effectiveness.

A consistent terminology is adopted throughout this study to strengthen clarity. The term strength training is used to refer to structured programmes involving progressive resistance exercises designed to improve muscular strength. While the literature often employs synonymous terms such as resistance training and muscle strength training, this review applies strength training uniformly, while acknowledging equivalence across the included studies.

Finally, given the diversity of study designs, intervention protocols, and outcome measures across the included literature, a narrative synthesis approach is employed. This method allows for thematic organisation and analysis of heterogeneous data, capturing variations in training intensity, frequency, duration, adherence measures, and quality-of-life outcomes. This approach ensures a comprehensive understanding of both the effectiveness and practical implementation of strength training programmes in this population.

3.2 Study Design

This systematic review is designed to evaluate the effectiveness of strength training interventions on the quality of life in adults with Type 2 diabetes. The review follows JBI guidelines and utilizes the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart to document the study selection process. Secondary data were sourced from multiple electronic databases, ensuring a comprehensive examination of the available literature. This design enables the evaluation of outcomes from diverse methodological approaches and provides a robust synthesis of the evidence. Adherence outcomes were included alongside primary QoL outcomes to strengthen the practical implications of findings.

3.3 Study Setting

Studies included in this review were conducted in various settings, including clinical environments, community health centres, and rehabilitation facilities. The study setting did not affect the inclusion of articles, as the primary focus was on the intervention outcomes rather than the environment in which the intervention was delivered. This approach allowed for a diverse collection of evidence reflecting real-world application of strength training programs.

3.4 Participants

3.4.1 Source of participants

Studies were sourced from multiple electronic databases covering literature published between 2012 and 2024. The search strategy was designed to identify studies that included adult diabetic patients participating in strength training programs.

3.4.2 Sample Size

The final sample comprised studies that met the predefined inclusion criteria. The total number of studies included was determined by the screening process, which involved title, abstract, and full-text reviews.

3.4.3 Sample Selection

3.4.3.1 Inclusion Criteria: Studies were eligible if they were published in English within the specified time frame (between January 2012 and June 2024), involved participants aged 18 years and older diagnosed with Type 2 diabetes, and evaluated the effects of strength training (or resistance exercise) which included structured or unstructured resistance-based exercise. Outcomes were reported on quality of life, measured by validated tools.

3.4.3.2 Exclusion Criteria: Studies were excluded if they included participants younger than 18 years, focused on populations without Type 2 diabetes, e.g. Type 1 Diabetes, gestational diabetes or mixed cohorts where results were not separated), and did not involve a strength training intervention.

The PICO framework was applied to guide the inclusion criteria (Table 1)

Table 1 PICO Outline

(P)articipants	Adult men and women aged 18 years and above, diagnosed with T2DM, studies published from 2012 to 2024 in English.
(I)ntervention	Studies that examined the effectiveness of Muscle Strength Training Programs. Studies describing strength training programs are considered.
(C)omparison	Different types of strength training including structured and unstructured training programs were compared.
(O)utcomes	Studies reporting on quality of life were considered. (Validated tool) Secondary: Adherence (dropout, retention, attendance).

This framework ensured that only adult participants with T2DM were included, focusing on studies that evaluated structured and unstructured program.

3.4.3 Study Selection

The JBI search strategy was utilized for study selection. An initial search was conducted on PubMed, followed by searches in SCOPUS, the Cochrane Library, ScienceDirect, and Embase.

The search strategy combined controlled vocabulary (e.g., MeSH terms) and free-text keywords relating to strength training, Quality of life, and Type 2 Diabetes Mellitus.
An example of the search string used in PubMed is as follows:
("Strength Training" OR "Resistance Training" OR "Muscle Training") AND ("Type 2 Diabetes Mellitus" OR "Diabetes Mellitus, Type 2") AND ("Quality of Life" OR "Health-Related Quality of Life")

Boolean operators, truncations, and filters were applied to refine the results. The reference lists of relevant reviews and included studies were also screened to identify additional eligible articles.

The selection process was documented using a PRISMA flow diagram (see Figure 3.1), which details the number of studies identified, screened, and included in the final analysis.

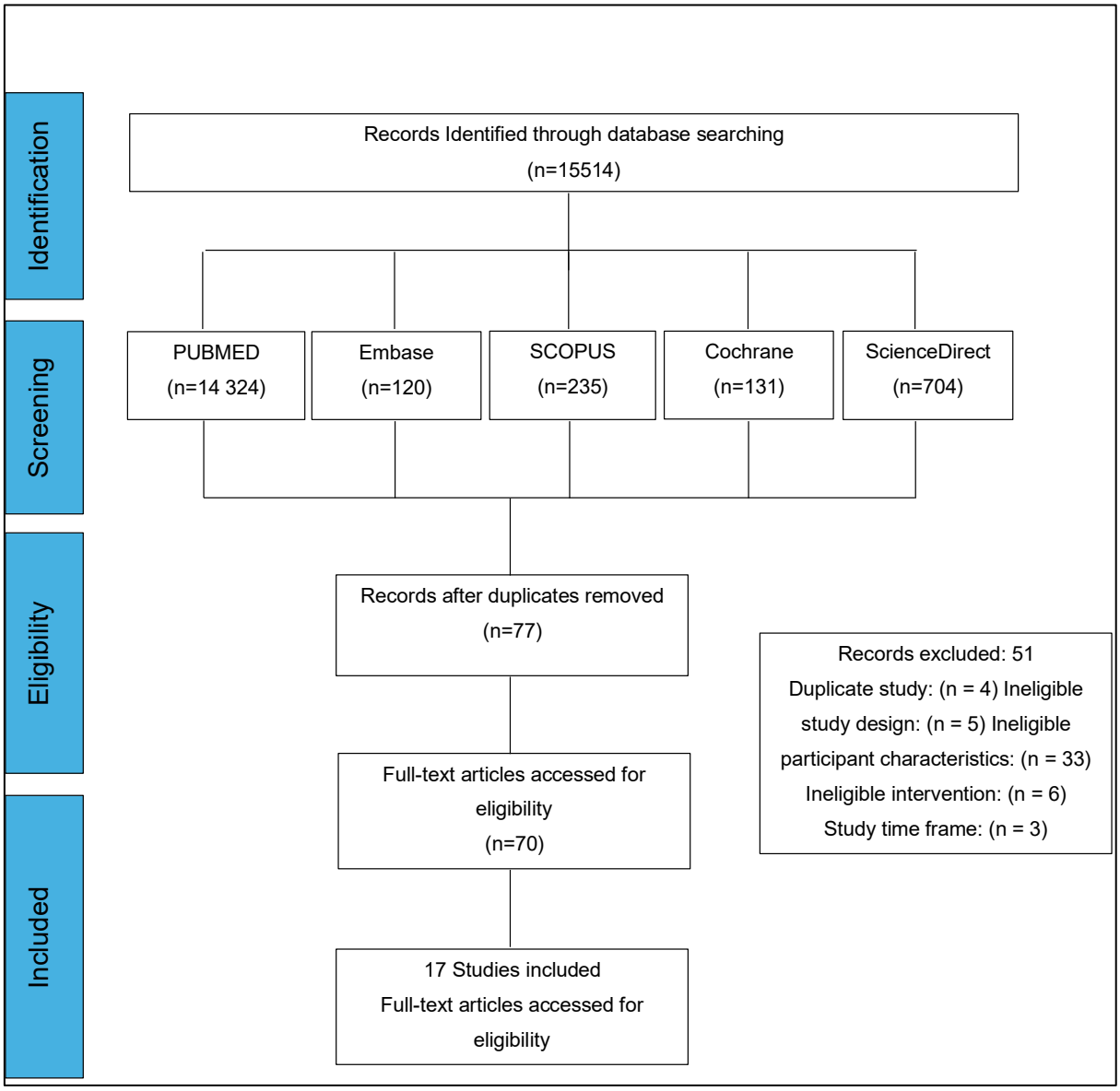


Figure 3-1 Search strategy and outcome: PRISMA flow diagram

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097.

3.5 Outcomes of Interest

3.5.1 Types of Outcome Measures

The outcome of interest in this review is the impact of strength training interventions on the quality of life (QoL) among adult diabetic patients. Quality of life is typically measured using validated instruments such as the SF-36, WHOQOL-BREF, or disease-specific questionnaires, which assess physical, emotional, and social well-being.

Adherence was considered a secondary but essential outcome. Where reported, data on participant retention, session attendance, dropout rates, and behavioural or technological support strategies were extracted. Including adherence measures provided insight into the feasibility and sustainability of interventions.

3.6 Procedure

3.6.1 Search Strategy

A three-step search strategy was implemented following the Joanna Briggs Institute (JBI) protocol for systematic reviews:

1. **Initial Search:** An initial search was conducted on PubMed using a set of keywords and index terms related to strength training and Type 2 diabetes. Keywords included "strength training," "resistance exercise," "quality of life," "Type 2 diabetes," "The titles, abstracts, and index terms of the identified articles were reviewed to refine the search strategy.
2. **Comprehensive Database Search:** Using the refined keywords, a second search was performed across multiple electronic databases, including PubMed, SCOPUS, the Cochrane Library, Embase, and ScienceDirect, and. The search was restricted to studies published in English from 2012 to 2024. This step ensured that all potentially relevant studies were captured.
3. **Reference List Screening:** The reference lists of all selected articles were examined to identify additional studies that met the inclusion criteria. This backward citation tracking helped to ensure that no relevant literature was overlooked.

3.6.2 Assessment of Methodological Quality

After the study selection process, the methodological quality of the included studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklists appropriate for the study designs (e.g., randomized controlled trials and observational studies and systematic reviews). The JBI System for the Unified Management, Assessment and Review of Information (SUMARI) software was employed to facilitate data extraction and quality assessment. Two independent reviewers critically appraised each study, and any disagreements were resolved through discussion. This rigorous appraisal process ensured that only high-quality evidence was synthesized in the final analysis.

This elaborated methodology section details the outcomes of interest, outlines the systematic search strategy, and explains the quality assessment process, providing a clear, replicable framework. These steps ensure that the findings on the effectiveness of strength training programs on the quality of life in adult diabetic patients are based on a robust and comprehensive analysis of existing literature.

Table 2 Description of JBI Appraisal Tool

Appraisal Tool	Description
Study	The title for each study included in the systematic review.
Author	The names of the authors of each study.
Review Questions	1. What is the effectiveness of strength training programs in improving quality of life (QoL) in adults with Type 2 diabetes Mellitus (T2DM)? 2. What types of strength training interventions are most effective for enhancing QoL in T2DM patients?
Keywords	Strength training, resistance exercise, weight training, quality of life, Type 2 diabetes Mellitus,
Participants	All studies that include adults diagnosed with T2DM who participated in strength training interventions. Studies involving participants aged 18 years and older with T2DM were included.
Interventions	Various forms of strength training interventions, including supervised, home-based, progressive resistance training, and combined resistance and aerobic exercise programs.
Outcome Measures	1. The impact of strength training on QoL, 2. The effectiveness of different strength training interventions on improving QoL in T2DM patients.
Types of Studies	Randomized controlled trials (RCTs), systematic reviews, meta-analyses that met the inclusion criteria.
Methods	JBI SUMARI software was used for critical appraisal by two independent reviewers.
Search Strategy	A three-step search strategy was implemented following JBI guidelines, including database searches, manual searches, and reference list scanning.
Information Sources	The databases searched included PubMed, Medline, Scopus, Cochrane Library and Embase.
Assessment of Methodological Quality	The JBI critical appraisal tool was used to evaluate the methodological quality of the included studies, ensuring reliability and validity.
Data Extraction	A standardized data extraction tool (JBI SUMARI) was used by two independent reviewers to extract relevant data on study characteristics, interventions, outcomes.
Data Synthesis	The data was synthesized narratively, justifying the inclusion and interpretation of findings.

This table outlines the key components of your JBI appraisal tool and provides a clear, concise description for each element used. It ensures transparency in how studies were selected, appraised, and synthesized to address the research objectives.

Table 3 Inclusion Criteria Guideline Checklist

Author:		**Reviewer:**	
Inclusion Criteria	Y	N	U
Population	☐	☐	☐
Age: ≥ 18 years	☐	☐	☐
Medical diagnosis: Type 2 Diabetes Mellitus (T2DM)	☐	☐	☐
Study Design	☐	☐	☐
Randomized Controlled Trial (RCT)	☐	☐	☐
Systematic Review & Meta-Analysis	☐	☐	☐
Excluded: Case reports, expert opinions, narrative reviews	☐	☐	☐
Intervention	☐	☐	☐
Strength training (e.g., resistance, progressive resistance training)	☐	☐	☐
Structured vs. unstructured resistance training	☐	☐	☐
Excluded: Studies focusing only on aerobic training	☐	☐	☐
Outcome Measures	☐	☐	☐
Outcome: Improvement in Quality of Life (QoL)	☐	☐	☐
Language & Timeframe	☐	☐	☐
Study published in English	☐	☐	☐
Publication date within the last 10 years (2012 to 2024)	☐	☐	☐

3.6.3 Data Collection

A standardized data extraction tool, implemented through the JBI SUMARI (System for the Unified Management, Assessment and Review of Information) software, was used to minimize errors and ensure consistency during data collection. The data extracted from each study included details on the interventions (i.e., various strength training protocols), participant characteristics (adults diagnosed with Type 2 diabetes), study design (experimental and non-experimental studies), and outcome (quality of life. Data was extracted, using a checklist (see Table 3.3 above) to verify that each study met the inclusion criteria. Only studies meeting the predefined criteria were included.

Zotero literature management software was used to manage the literature search records.

3.6.4 Data Synthesis

Data were extracted systematically, capturing details such as authors, year of publication, country of origin, study setting, participant demographics, intervention characteristics, outcome measures, and key findings. Given the heterogeneity of the study designs and outcome measures among the included studies, the data were synthesized using a narrative approach. This narrative synthesis allows for a comprehensive comparison of the effectiveness of different strength training interventions on quality of life in diabetic patients. Summary tables were created to display similarities and differences across studies, enabling a clear interpretation of the overall evidence.

3.6.5 Statistical Analyses

Due to the significant heterogeneity observed among the studies in terms of design, interventions, and outcome measures, statistical pooling (i.e., meta-analysis) was not feasible. Instead, the findings from the selected studies were presented in a narrative format, complemented by summary tables. This approach ensured that the complexity of the evidence base was respected while maintaining analytical rigor.

3.7 Ethical Considerations

Since it is secondary research human participants are not approached for data collection. During data collection and their integration within the current research, document references and citations have been extensively adopted for projecting the application of external information by providing due credit to the author of the article from which data has been used. The research work contains original data that has been collected by the researcher using secondary research principles. It is an original work which has not been copy-pasted from any external source like AI or another author. This eliminates ethical issues like plagiarism and copyright. An ethical clearance waiver was not necessary for this systematic review according to the University of Witwatersrand's Human Research Ethics Committee (HREC) guidelines (https://www.wits.ac.za/media/wits-university/research/documents/HREC(Med)ClearanceProcedures.pdf). Since this study relied solely on secondary data from published literature and did not involve human participants directly, formal ethics approval was not required. As stated by the HREC, "If no ethics approval (human or animal) is required, this will be recorded at the protocol assessors meeting. In instances where a journal requires an ethics waiver

certificate for publication of research, the HREC Chair can be approached to issue an ethics waiver certificate."

3.8 Conclusion of the methodology

In this secondary research, the inclusion criteria have been developed using the PICO method. Participants include adults who are above the age of 18 diagnosed with Type 2 diabetes and studies considered include those conducted from 2012 until 2024 and focus on interventions relating to muscle strength training programs where the outcome emphasises quality of life. Keywords used in the study process include Resistance Training, Quality of Life and Diabetes Mellitus. The adopted data collection instrument is JBI SUMARI. Select databases are used for data collection which include PubMed, SCOPUS, Embase, Cochrane Library, and ScienceDirect. This chapter has detailed the methodology adopted for this systematic review, including the study design, study setting, participant selection, and the inclusion and exclusion criteria. The procedures for data collection, quality appraisal using the JBI SUMARI software, data synthesis, and the rationale for not performing statistical pooling due to heterogeneity were also discussed. Together, these methods ensure a rigorous and transparent review process. The findings derived from this methodology are presented in Chapter 4.

Chapter 4 Results

4.1 Introduction

The results of the review are presented in this chapter in a narrative form, as the included studies were heterogeneous, and statistical pooling was not always appropriate. Tables and figures supplement the narrative to illustrate the findings. This chapter details the settings, samples, participant characteristics, outcome measures, and the methodological quality of the included studies.

4.2 Description of Studies

A total of 15514 articles were initially identified from the comprehensive database search. After screening titles and abstracts, 77 full-text articles were assessed for eligibility. Of these, 27 studies were excluded for various reasons, which are summarized in Table 4.1. The reasons for exclusion included:

- Review articles and meta-analyses: 10 studies were excluded because they were not original randomized controlled trials.
- Irrelevant outcome measures: 7 studies did not report quality of life outcomes.
- Non-exercise interventions**:** 5 studies focused solely on dietary interventions without an exercise component.
- Inadequate study design**:** 3 studies employed observational or non-randomized designs.
- Other reasons**:** 2 studies were excluded due to being study protocols or pilot studies that did not meet our criteria.

Table 4 Excluded Studies

Authors	Title	Year	Reason for Exclusion
Lift for Life® study (Reference)	*The effects of a community-based strength training program (Lift for Life®) on physical activity behaviour, functional performance and quality of life in older adults with type 2 diabetes*	2007	Ineligible participant characteristics (population did not match our target criteria)
Teychenne et al.	*Adoption and maintenance of gym-based strength training in the community setting in adults with excess weight or type 2 diabetes: a randomized controlled trial*	2015	Ineligible participant characteristics (focused on overweight individuals rather than our broader adult diabetic population)
Al Ozairi et al.	*Protocol for a randomised controlled trial to investigate the effect of home- and gym-based resistance exercise training on glycaemic control, body composition and muscle strength*	2020	Ineligible participant characteristics (protocol only; no outcome data)
Lincoln et al.	*The Impact of Resistance Exercise Training on the Mental Health of Older Puerto Rican Adults With Type 2 Diabetes*	2011	Ineligible participant characteristics (focused on a specific ethnic subgroup not representative of our target population)
Geirsdottir et al.	*Effect of 12-Week Resistance Exercise Program on Body Composition, Muscle Strength, Physical Function, and Glucose Metabolism in Healthy, Insulin-Resistant, and Diabetic Elderly Icelanders*	2012	Ineligible participant characteristics (focused on an elderly subgroup not aligned with our inclusion criteria)
Nambi et al.	*Role of Tele-Physical Therapy Training on Glycemic Control, Pulmonary Function, Physical Fitness, and Health-Related Quality of Life in Patients with Type 2 Diabetes Mellitus Following COVID-19 Infection*	2023	Ineligible intervention (tele-physical therapy is not a traditional, supervised strength training program)
Chang & Liu	*Effects of combined resistance training and Tai Chi on oxidative stress, blood glucose and lipid metabolism and quality of life in elderly patients with type 2 diabetes mellitus*	2024	Ineligible intervention (combined modality does not isolate pure strength training)
Collins et al.	*Amount and intensity effects of exercise training alone versus a combined diet and exercise lifestyle intervention on health-related quality of life in the STRRIDE-PD randomized trial*	2022	Ineligible participant characteristics (focused on overweight/prediabetic individuals with combined diet interventions)

Authors	Title	Year	Reason for Exclusion
Qadir et al.	*Effectiveness of Resistance Training and Associated Program Characteristics in Patients at Risk for Type 2 Diabetes: A Systematic Review and Meta-analysis*	2021	Ineligible participant characteristics (targeted at-risk individuals rather than those with established type 2 diabetes)
Zhang et al.	*Effectiveness of Combined Aerobic and Resistance Exercise on Cognition, Metabolic Health, Physical Function, and Health-related Quality of Life in Middle-aged and Older Adults with T2DM: A Systematic Review and Meta-analysis*	2024	Ineligible intervention (combined aerobic and resistance exercise; our review focuses solely on pure strength training programs)
Mediterranean Diet, Circuit Resistance Training, Empagliflozin in Elderly with Type 2 Diabetes (Study Protocol)	*Mediterranean Diet, Circuit Resistance Training, Empagliflozin in Elderly with Type 2 Diabetes: A Study Protocol*	2018	Ineligible participant characteristics (focus on elderly subjects with a combined intervention not aligning with our criteria)
RBR-3srpth8	*Strength exercise, cognitive stimulation and type 2 Diabetes on aging*	2024	Ineligible intervention (includes cognitive stimulation alongside strength training, deviating from a pure strength training focus)
ISRCTN97865321	*Finding the Optimal Resistance Training Exercise for Type 2 Diabetes*	2010	Ineligible participant characteristics/study time frame (does not meet our current inclusion criteria)
ChiCTR2300070726	*Effects of Elastic Band Resistance Training in Pre-Frail Elderly Patients with Type 2 Diabetes Mellitus*	2023	Ineligible participant characteristics (focused on pre-frail elderly, not representative of the broader adult diabetic population)
Lazarus, ER	*Effectiveness of Education and Exercise on Quality of Life among Patients Undergoing Haemodialysis*	2019	Ineligible participant characteristics (study population undergoing haemodialysis, not type 2 diabetes)
Collins et al.	*Amount and intensity effects of exercise training alone versus a combined diet and exercise lifestyle intervention on health-related quality of life in the STRRIDE-PD randomized trial*	2022	Ineligible participant characteristics (targeted overweight/prediabetic individuals with combined diet interventions)

Included studies

The systematic review identified 18 studies. These studies met the inclusion criteria after independent appraisal which was done by two reviewers. The studies comprised both randomized controlled trials (RCTs) and systematic reviews. The research articles that were chosen were conducted across multiple continents. This demonstrated global interest in exercise interventions for managing diabetes. Three studies originated from North and South America: USA, Canada and Brazil (Myers et al.,2013), (Mager et al.,2021 and Bassi et al., 2016), one from Australia (Formica et al.,2023), two from Europe: Turkey and Italy (Akinci et al.,2018 and Nicolucci et al.,2012), seven from Asia: Sri Lanka, Pakistan, Singapore, India, Taiwan, and Japan (Ranasinge et al., 2018, Haleem et al., 2024, Venkataraman et al.,2019, Amaravadi et al.,2024, Chien et al.,2022, and Kobayashi et al.,2023).

By having a broad geographic distribution, this suggests that the findings are applicable across different healthcare settings and populations, thereby allowing us to generalize the results.

The intervention settings varied across studies, reflecting the adaptability of strength training programs. Many interventions were conducted in hospital-based programs under professional supervision, ensuring adherence and safety. Several studies implemented strength training within community health centres, providing accessible exercise opportunities in a local healthcare context. Some of the studies examined home-based programs where participants performed resistance exercises independently, often using minimal equipment like resistance bands or body-weight exercises Phone check-ins were common strategies in these home-based regimens to promote adherence as well as telemonitoring. In certain cases, interventions were conducted in rehabilitation facilities specializing in chronic disease management. The different intervention settings highlights that strength training can be effectively delivered in both supervised and unsupervised environments, although adherence levels often depended on the degree of professional support available.

The primary focus of this systematic review was to evaluate the effects of strength training interventions on health-related quality of life (QoL) in adults with T2DM. Most studies utilized validated QoL measurement tools such as the Short Form-36 Health Survey (SF-36), Diabetes Quality of Life (DQOL) questionnaire, or WHOQOL-BREF to

assess changes in participants' quality of life before and after the interventions. The majority of studies reported that structured strength training programs led to significant improvements in overall QoL scores, particularly in the physical health and functional domains Perception of quality of life was higher in participants who engaged in supervised resistance training interventions. These participants experienced enhanced mobility, reduced fatigue, and greater ease in performing daily activities.

Psychological and emotional well-being also improved among individuals who participated in strength training programs. Several studies found that resistance training reduced symptoms of depression, anxiety, and diabetes-related distress This is probably due to improvement in physical capacity and self-efficacy as well as positive social interactions that is associated with supervised exercise programmes. Additionally, home-based strength training interventions, which are generally effective, showed more variability in their impact on QoL. Some studies reported significant QoL improvements, while others found no substantial changes. This is potentially due to differences in participant adherence and motivation levels where there is no direct supervision.

Adherence to strength training interventions plays a vital role in determining their effectiveness. Studies with higher adherence rates, typically those conducted in supervised settings, demonstrated the most significant improvements in QoL. On the other hand, home-based interventions, which required greater self-motivation, sometimes faced challenges with adherence, impacting the extent of QoL benefits observed. To increase the benefits of strength training for QoL in Type 2 diabetes patients, future research should explore strategies to enhance long-term adherence, particularly in home-based and community-based programs.

Table 5 Included Studies

Authors	Title	Type of Study	Country	Setting	Reason for Inclusion
Venkataraman et al. (2019)	Short-term strength and balance training does not improve quality of life but improves functional status in individuals with diabetic peripheral neuropathy: a randomised controlled trial	RCT	Singapore	Clinical setting	Examines the effect of strength and balance training on QoL and functional status in diabetic patients with neuropathy.
Ranasinghe et al. (2018)	Study protocol: a randomised controlled trial of supervised resistance training versus aerobic training in Sri Lankan adults with type 2 diabetes mellitus: SL-DART study	RCT	Sri Lanka	Hospital-based	Investigates the comparative effects of resistance vs. aerobic training on quality of life in a South Asian diabetic population.
Sisir et al. (2019)	Effects of Different Volume of Resistance Training on Bioimpedance Phase Angle, Muscular Strength, and Quality of Life among Diabetes Patients	RCT	Malaysia	Clinical setting	Evaluates how different resistance training volumes impact muscle strength and QoL in diabetic patients.
Nicolucci et al. (2012)	Relationship of exercise volume to improvements of quality of life with supervised exercise training in patients with type 2 diabetes in a randomised controlled trial: the Italian Diabetes and Exercise Study (IDES)	RCT	Italy	Clinical setting	Assesses the impact of different exercise volumes on QoL and adherence.
Haleem et al. (2024)	Combined effects of strength and balance training versus aerobic training on balance, neuropathy symptoms, and quality of life in patients with diabetic peripheral neuropathy	RCT	Pakistan	Hospital-based	Investigates the impact of strength and balance training on neuropathy symptoms, balance, and QoL in diabetic patients.
Al Ozairi et al. (2023)	The effect of home-based resistance exercise training in people with type 2 diabetes: a randomized controlled trial	RCT	Kuwait	Home-based	Evaluates the effectiveness of home-based resistance training on QoL, muscle mass, and functional capacity in diabetic patients.
Mager et al. (2021)	Effect of a Resistance Exercise Intervention on Frailty Outcomes in Adults With Diabetes Mellitus	RCT	Canada	Community-based	Examines resistance training's role in improving frailty, physical function, and QoL in diabetic patients.
Akinci et al. (2018)	The effects of internet-based exercise compared with supervised group exercise in people with type 2 diabetes: a randomized controlled study	RCT	Turkey	Internet-based & clinical setting	Compares internet-based vs. supervised exercise interventions on QoL and adherence.
Bassi et al. (2016)	Potential effects on cardiorespiratory and metabolic status after a concurrent strength and endurance	RCT	Brazil	Clinical setting	Examines the impact of concurrent strength and endurance training on metabolic health and QoL.

Authors	Title	Type of Study	Country	Setting	Reason for Inclusion
	training program in diabetes patients -- a randomized controlled trial				
Chien et al. (2022)	Effects of 12-week progressive sandbag exercise training on glycemic control and muscle strength in patients with type 2 diabetes mellitus combined with possible sarcopenia	RCT	Taiwan	Clinical setting	Investigates progressive resistance training (sandbag exercises) for diabetic patients with sarcopenia, assessing QoL and glycemic control.
Amaravadi et al. (2024)	Effectiveness of structured exercise program on insulin resistance and quality of life in type 2 diabetes mellitus–A randomized controlled trial	RCT	India	Hospital-based	Evaluates structured resistance and aerobic exercise programs on QoL, insulin resistance, and glycemic control.
Myers et al. (2013)	Exercise training and quality of life in individuals with type 2 diabetes: a randomized controlled trial	RCT	USA	Clinical setting	Assesses the effects of aerobic, resistance, and combined training on QoL in diabetic individuals.
Jia et al. (2024)	The effects of resistance exercises interventions on quality of life and glycemic control in patients with type 2 diabetes: Systematic review and meta-analysis of randomized controlled trials	Systematic Review & Meta-Analysis	Global	Various clinical settings	Systematic review assessing the effectiveness of resistance training on QoL and glycemic control.
Sabag et al. (2023)	The Effect of Exercise on Quality of Life in Type 2 Diabetes: A Systematic Review and Meta-analysis	Systematic Review & Meta-Analysis	Global	Various settings	Systematic review evaluating various exercise interventions and their effectiveness in improving QoL in diabetic patients.
Formica et al. (2023)	Effects of a Multi-component, Resistance-Based Exercise Program Combined with Additional Lean Red Meat on Health-Related Quality of Life in Older Adults: Secondary Analysis of a 6-Month Randomized Controlled Trial	RCT	Australia	Clinical setting	Investigates the combined effects of resistance training and dietary interventions on QoL in older diabetic adults.
Kobayashi et al. (2023)	Strength training is more effective than aerobic exercise for improving glycaemic control and body composition in people with normal-weight type 2 diabetes: a randomised controlled trial	RCT	Japan	Clinical setting	Compares the impact of strength vs. aerobic training on glycemic control, body composition, and QoL.
Cai et al. (2017)	Effect of exercise on the quality of life in type 2 diabetes mellitus: a systematic review	Systematic Review	Global	Various settings	Systematic review evaluating different exercise modalities on QoL outcomes in diabetic individuals.

Authors	Title	Type of Study	Country	Setting	Reason for Inclusion
Qadir et al. (2021)	Effectiveness of Resistance Training and Associated Program Characteristics in Patients at Risk for Type 2 Diabetes: A Systematic Review and Meta-analysis	Systematic Review & Meta-Analysis	Global	Various settings	Reviews the role of resistance training in preventing type 2 diabetes and its effects on QoL.

4.3 Methodological Quality Assessment

The methodological quality of the included studies in this systematic review was assessed using the JBI SUMARI critical appraisal tools. This tool was used to evaluate randomized controlled trials (RCTs) and systematic reviews/meta-analyses based on key methodological criteria. The assessment was conducted independently by two reviewers to ensure reliability.

Among the included studies, 14 were RCTs, providing high-level evidence on the effects of strength training on quality of life in individuals with T2DM. The highest-rated RCT was Venkataraman et al. (2019), which scored 12/13, demonstrating strong methodological rigor, including proper randomization, follow-up, and objective outcome assessment. Other high-scoring RCTs included Al Ozairi et al. (2023), Bassi et al. (2016), and Amaravadi et al. (2024), all of which met key methodological criteria for randomization, blinding, and outcome measurement, ensuring high internal validity.

Some RCTs had methodological weaknesses, with unclear allocation concealment and blinding procedures, which may introduce bias in outcome assessments. For instance, Mager et al. (2021), Akinci et al. (2018), Myers et al. (2013), and Chien et al. (2022) had multiple "unclear" (U) ratings, particularly regarding participant allocation and intervention adherence, which suggested a moderate risk of bias. Studies such as Haleem et al. (2024), Sisir et al. (2019), and Ranasinghe et al. (2018) demonstrated moderate-to-high quality but had limitations in reporting intervention commitment and adherence levels. Despite some methodological weaknesses, all RCTs were included in the review due to their relevance to strength training interventions and quality of life outcomes.

In addition to RCTs, four systematic reviews and meta-analyses were included. Systematic reviews strengthen the evidence base by synthesizing results from multiple studies. Sabag et al. (2023) and Qadir et al. (2021) were the highest-rated systematic reviews, each scoring 11/11, indicating excellent methodological rigor in study selection, search strategy, and risk of bias assessment. These reviews provided strong supporting evidence on the benefits of resistance training for quality of life in adults with Type 2 diabetes. Jia et al. (2024) and Cai et al. (2017) had slightly lower scores

(9/11 and 10/11, respectively) due to unclear reporting on risk of bias assessments, though they remained valuable in evaluating various strength training interventions on diabetes-related quality of life.

Overall, the methodological quality of the included studies was moderate to high, with most RCTs demonstrating rigorous study designs and systematic reviews/meta-analyses strengthening the overall findings. Some concerns regarding bias and adherence were noted, particularly in studies with unclear allocation concealment and intervention fidelity reporting. Despite these limitations, the inclusion of both controlled trials and broader research syntheses ensures a comprehensive and balanced analysis of how strength training interventions impact the quality of life in individuals with T2DM.

Table 6 RCT Critical Appraisal Scores

Citation	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13
Venkataraman K, Tai BC, Khoo EYH, Tavintharan S, Chandran K, Hwang SW, et al. 2019.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
Sisir MF, Raja Azidin RMF, Hasan H, Abdul Ghani R, Omar M, Ismail H. 2019.	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
Haleem F, Saeed A, Kundi M, Jalal A, Bilal M, Jalal M. 2024.	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y
for the Italian Diabetes Exercise Study (IDES) Investigators, Nicolucci A, Balducci S, Cardelli P, Cavallo S, Fallucca S, et al. 2012.	Y	Y	Y	Y	N	Y	N	U	Y	Y	Y	Y	Y
Al Ozairi E, Alsaeed D, Al Roudhan D, Jalali M, Mashankar A, Taliping D, et al. 2023.	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
Mager D, Kamprath C, Wilmott A, Robinson-Jackson M, Juby A, Boule N, et al. 2021.	Y	U	Y	N	N	U	Y	Y	Y	Y	Y	Y	Y
Akinci B, Yeldan I, Satman I, Dirican A, Ozdincler AR. 2018.	Y	U	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
Myers VH, McVay MA, Brashear MM, Johannsen NM, Swift DL, Kramer K, et al. 2013.	Y	U	Y	N	N	U	Y	Y	Y	Y	Y	Y	Y
Amaravadi SK, Maiya GA, K. V, Shastry BA. 2024.	Y	Y	Y	Y	U	Y	U	U	Y	Y	Y	Y	Y
Chien Y-H, Tsai C-J, Wang D-C, Chuang P-H, Lin H-T. 2022.	Y	U	U	Y	U	U	Y	U	U	Y	Y	Y	Y
Subramanian SS, Julius A, Hariharasudan R. 2014.	Y	Y	N	N	N	N	N	U	Y	Y	Y	Y	Y
Bassi D, Mendes RG, Arakelian VM, Caruso FCR, Cabiddu R, Junior JCB, et al. 2016.	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
Formica MB, Gianoudis J, Nowson CA, O'Connell SL, Milte C, Ellis KA, et al. 2023.	Y	Y	Y	Y	N/A	N/A	Y	Y	Y	Y	Y	Y	Y

Kobayashi Y, Long J, Dan S, Johannsen NM, Talamoa R, Raghuram S, et al. 2023.	Y	Y	Y	N	N	Y	Y	N	Y	Y	Y	Y	Y
Formica MB, Gianoudis J, Nowson CA, O'Connell SL, Milte C, Ellis KA, et al. 2023.	Y	U	Y	N	U	U	Y	Y	Y	Y	Y	Y	Y
Ranasinghe C, Hills AP, Constantine GR, Finlayson G, Katulanda P, King NA. 2018.	Y	Y	Y	N	N	Y	Y	N	Y	Y	Y	Y	Y
%	100.0	68.75	87.5	37.5	6.25	62.5	75.0	62.5	93.75	100.0	100.0	100.0	93.75

Table 7 Critical Appraisal of Eligible Systematic Review

Citation	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**
SABAG A, CHANG CR, FRANCOIS ME, KEATING SE, COOMBES JS, JOHNSON NA, et al. 2023.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Jia J, Xue Y, Zhang YC, Hu Y, Liu S. 2024.	Y	Y	Y	Y	Y	Y	Y	Y	N	U	Y
Cai H, Li G, Zhang P, Xu D, Chen L. 2017.	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
Qadir R, Sculthorpe NF, Todd T, Brown EC. 2021.	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	50.0	75.0	100.0

4.4 Sample

The total number of participants included in this review was 4,378 across all included studies. The studies recruited participants through various methods, including randomized controlled trials (RCTs) and systematic reviews/meta-analyses, ensuring a broad representation of the diabetes populations. The RCTs determined sample sizes based on power analysis calculations, while some systematic reviews synthesized data from multiple trials to assess overall trends.

Several studies conducted recruitment in hospital and clinical settings, while others included community-based or home-based interventions. For instance, Ranasinghe et al. (2018) recruited participants through diabetes management clinics in Sri Lanka, while Al Ozairi et al. (2023) conducted recruitment for a home-based resistance training intervention through public health initiatives and diabetes education programs.

4.5 Participants

The primary characteristic of the participants in the included studies was their diagnosis of Type 2 Diabetes Mellitus (T2DM). Most participants had varying levels of glycemic control and were engaged in different strength training interventions aimed at improving quality of life (QoL).

The age range of participants varied across studies, with most trials including middle-aged to older adults (typically 40–75 years old), as this population is particularly susceptible to diabetes-related complications, muscle weakness, and reduced physical function. Some studies, such as Nicolucci et al. (2012), categorized participants based on age groups (e.g., under 60 vs. over 60 years old) to assess potential age-related differences in response to strength training interventions.

Comorbidities were common among participants, including diabetic neuropathy, obesity, cardiovascular disease, and sarcopenia, which are known to impact both exercise adherence and quality of life. Some studies specifically targeted individuals with diabetic complications to evaluate the additional benefits of strength training in disease management and functional improvement. Haleem et al. (2024), for example, focused on diabetic peripheral neuropathy, assessing how strength and balance training influenced neuropathy symptoms and overall QoL.

4.6 Interventions

The studies included in this review investigated various forms of strength training interventions, categorized into the following:

1. Supervised Resistance Training Programs (clinic-based or hospital-based)
2. Home-Based Strength Training Regimens
3. Combined Strength and Aerobic Training Interventions
4. Progressive Resistance Training Programs

Supervised Resistance Training Programs

Several studies implemented structured resistance training interventions in clinical or rehabilitation settings. These programs often included machine-based exercises, free weights, and resistance bands, with exercise physiologists or physiotherapists supervising training sessions.

For instance, Nicolucci et al. (2012) required participants to attend biweekly supervised strength training sessions for 12 weeks, focusing on lower-body and upper-body resistance exercises to enhance muscle strength, glycemic control, and QoL. Similarly, Mager et al. (2021) implemented resistance training in frail diabetic adults, demonstrating improvements in frailty outcomes and QoL.

Home-Based Strength Training Regimens

Some studies examined home-based strength training interventions, which provided participants with structured exercise guidelines, resistance bands, and video-assisted programs to perform unsupervised training. These programs aimed to increase accessibility and adherence, particularly for individuals with mobility limitations or lack of access to fitness facilities.

For example, Al Ozairi et al. (2023) evaluated a 12-week home-based resistance training program, showing improvements in QoL, muscular strength, and daily physical function, despite the absence of direct supervision.

Similarly, Akinci et al. (2018) compared internet-based strength training with supervised group exercise, finding that both interventions improved QoL, but adherence rates were higher in the supervised group.

Combined Strength and Aerobic Training Interventions

Several studies explored multi-modal exercise programs, integrating strength training with aerobic components (e.g., walking, cycling, or treadmill workouts). These programs were included based on evidence suggesting synergistic effects on metabolic health, cardiovascular fitness, and QoL.

For example, Ranasinghe et al. (2018) compared resistance-only training vs. combined resistance-aerobic training, reporting superior improvements in physical function and psychological well-being in the combined group. Additionally, Bassi et al. (2016) investigated combined strength and endurance training, finding significant improvements in cardiopulmonary fitness but minimal effects on QoL.

Progressive Resistance Training Programs

Progressive resistance training (PRT) was implemented in studies where participants gradually increased exercise intensity over time, ensuring continued strength gains and metabolic adaptations. These programs typically involved increasing resistance loads, repetitions, or exercise complexity every few weeks.

For example, Chien et al. (2022) conducted a progressive sandbag-based strength training intervention, leading to significant QoL improvements, enhanced glycemic control, and increased lower-body muscle mass.

Similarly, Kobayashi et al. (2023) demonstrated that progressive strength training significantly reduced HbA1c and improved QoL compared to aerobic exercise, particularly in normal-weight diabetes patients

Table 8 Summary of the findings

Authors	Study Type	Intervention Type	Intervention Period	Outcomes & Results	Key Challenges	Focus
Myers et al. (2013)	RCT	Aerobic, resistance, and combined training	9 months	Improved physical QoL in T2DM patients, limited effect on mental QoL. Combined aerobic and resistance training had greater benefits.	Adherence to long-term interventions.	To establish whether exercise improves QoL in T2DM and determine which exercise types are most beneficial
Formica et al. (2023)	RCT	Multi-component resistance-based exercise + lean red meat	6 months	No significant impact on QoL in older adults consuming lean red meat while exercising.	Difficulty in dietary adherence	To assess whether lean red meat consumption enhances exercise benefits on QoL in older adults
Sabag et al. (2023)	Systematic Review & Meta-Analysis	Aerobic and resistance training	Various durations (meta-analysis)	Regular aerobic exercise alone or combined with resistance training improved QoL in adults with T2DM. Improvements were linked to physical HR-QoL and better glycemic control (HbA1c reduction).	Further studies needed on exercise duration, intensity, and frequency	To examine the impact of different exercise modalities on QoL in T2DM
Kanaley et al. (2022)	Consensus Statement	Various physical activity types	Ongoing research (since 2010)	Resistance, aerobic, and flexibility training improve health and glycemic control in T2DM. Physical activity should be incorporated into daily routines.	Tailoring exercise for those with complications	Guidelines for exercise and physical activity in T2DM patients
Cai et al. (2017)	Systematic Review	Aerobic, resistance, and combined exercise	Various durations (meta-analysis)	Aerobic exercise significantly improved QoL, whereas resistance and combined training had mixed results.	Limited studies on resistance training impact	To evaluate the effect of exercise on QoL in T2DM patients
Amaravadi et al. (2024)	RCT	Structured aerobic, resistance, and combined exercise	12 weeks	Improved insulin resistance, functional capacity, and all QoL domains (physical, psychological, social, environmental).	Ensuring participant adherence	To assess the impact of structured exercise on insulin resistance and QoL in T2DM
Jia et al. (2024)	Systematic Review & Meta-Analysis	Resistance training	Various durations (meta-analysis)	Marginal effects on physical QoL, no significant impact on mental QoL or glycemic control	Lack of clear connection between resistance training and mental components	To analyze the effectiveness of resistance training on QoL and glycemic control in T2DM
Ranasinghe et al. (2018)	RCT	Supervised resistance vs. aerobic training	12 weeks	Compared effects of both exercise types on QoL in South Asian diabetic patients.	Adherence to structured programs	To assess the effects of resistance vs. aerobic

Authors	Study Type	Intervention Type	Intervention Period	Outcomes & Results	Key Challenges	Focus
				Resistance training was beneficial but aerobic had greater impact on mental QoL.		training on QoL in Sri Lankan adults with T2DM
Nicolucci et al. (2012)	RCT	Supervised resistance training (varied volume)	6 months	Higher volume of supervised training improved QoL, adherence, and physical function	Maintaining high adherence rates	To examine the relationship between exercise volume and QoL in T2DM
Haleem et al. (2024)	RCT	Strength & balance training vs. aerobic	8 weeks	Significant improvements in neuropathy symptoms and balance, leading to better QoL	Fear of injury in participants with neuropathy	To evaluate how balance and strength training affects QoL in diabetic patients with neuropathy
Sisir et al. (2019)	RCT	Different resistance training volumes	12 weeks	Higher training volume improved muscle strength and bioimpedance phase angle but had limited impact on QoL.	Motivation to maintain consistency in high-volume training	To evaluate the impact of different resistance training volumes on QoL in diabetic patients
Al Ozairi et al. (2023)	RCT	Home-based resistance training	32 weeks	No significant HbA1c reduction, but increased muscle mass and functional capacity.	Reduced motivation without supervision	To evaluate the effectiveness of home-based resistance training on QoL
Mager et al. (2021)	RCT	Resistance training in frail diabetic adults	6 months	Improved frailty outcomes and QoL	Adherence in frail populations	To examine how resistance training impacts frailty and QoL in diabetic patients
Akinci et al. (2018)	RCT	Internet-based vs. supervised exercise	8 weeks	Both interventions improved QoL, but adherence was higher in supervised group	Accessibility to supervised programs	To compare internet-based and supervised exercise interventions on QoL
Bassi et al. (2016)	RCT	Combined strength & endurance training	12 weeks	Improved cardiopulmonary fitness, minimal effect on QoL	Balancing endurance and strength training intensity	To evaluate how concurrent strength and endurance training affects QoL in T2DM
Chien et al. (2022)	RCT	Progressive sandbag resistance training	12 weeks	Significant improvements in QoL, glycemic control, and muscle mass	Participant adherence and motivation	To assess the effectiveness of progressive resistance training for diabetic patients with sarcopenia

Authors	Study Type	Intervention Type	Intervention Period	Outcomes & Results	Key Challenges	Focus
Kobayashi et al. (2023)	RCT	Strength vs. aerobic training	9 months	Strength training reduced HbA1c and improved QoL more than aerobic training. No difference between strength-only and combined training.	Tailoring programs to different body compositions	To compare strength vs. aerobic training on glycemic control and QoL
Qadir et al. (2021)	Systematic Review & Meta-Analysis	Resistance training	Various durations (meta-analysis)	Improved glycemic control, body fat percentage, and blood lipids in those at risk for T2DM	Adherence to long-term resistance training	To evaluate the impact of resistance training on diabetes prevention and QoL

Synthesis of Findings

Structured vs. Unstructured Strength Training Programs

Structured strength training programs consistently demonstrated better adherence and significant improvements in physical and mental health outcomes. Supervised settings with professional guidance e.g., Sisir et al. (2012), resulted in enhanced physical QoL, including muscle strength, body composition, and glycemic control. Structured programs were associated with improved mental health outcomes, such as reduced anxiety and depression symptoms, although these effects were moderate.

In contrast, unstructured programs, often conducted at home or remotely, showed inconsistent effects. Studies like Akinci et al. (2017) and Al Ozairi et al. (2023), reported improvements in physical health metrics, including muscle strength and balance, but limited effects on mental health and emotional QoL. Mixed results were probably due to lack of professional oversight and accountability.

Effectiveness of Strength Training Programs on Quality of life

Physical Quality of Life:

Across all studies, strength training consistently demonstrated positive effects on the physical components of quality of life (QoL) in individuals with Type 2 Diabetes Mellitus (T2DM). Improvements were noted in mobility, functional independence, and overall physical well-being. Studies such as Venkataraman et al. (2019) and Amaravadi et al. (2024) reported significant improvements in physical function, as measured by performance-based tests like the 6-minute walk test (6MWT) and grip strength assessments. Strength training interventions, particularly longer-duration and supervised programs, were associated with greater adherence and more evident improvements in QoL. Additional studies found that reductions in diabetes-related complications, such as neuropathy symptoms and fatigue, contributed to an overall improvement in physical quality of life.

Mental health-related QoL outcomes were more inconsistent across studies. While some research, such as Mager et al. (2021), reported moderate improvements in mental well-being, others, such as Al Ozairi et al. (2023), found no significant changes. Factors such as social engagement, motivation, and psychological support appeared to play a role in whether participants experienced mental health benefits from strength

training. This suggests that integrating psychosocial interventions, such as group training sessions and behavioural counselling, alongside strength training could enhance mental QoL outcomes in T2DM patients. Further research is needed to explore how different exercise modalities and support strategies influence mental well-being in this population.

Adherence Factors

Adherence emerged as a critical determinant of programme effectiveness. Supervised or structured interventions consistently demonstrated higher adherence rates, particularly when they incorporated progress monitoring, goal setting, and personalised feedback. These elements increased accountability and motivation, supporting long-term commitment to strength training.

In contrast, unstructured or unsupervised programmes, although convenient, were associated with lower adherence rates due to reduced external accountability. Technological solutions such as videoconferencing and remote monitoring (Akinci et al., 2017) showed potential for bridging this gap but remained less effective than in-person supervision.

Programmes that incorporated group dynamics and peer support (e.g., Sisir et al., 2012) reported not only higher adherence but also improved psychological outcomes, reflecting the motivational value of social interaction.

Framing these findings within behavioural theories helps explain why supervised and socially supported interventions outperform home-based ones. For instance:

- According to Self-Determination Theory (SDT), (Ryan & Deci 2000), the autonomy, competence, and relatedness fostered in supervised and group-based settings enhance intrinsic motivation.
- The Health Belief Model (HBM) suggests that supervised feedback reinforces participants' perception of benefits while reducing perceived barriers. (Champion & Skinner, 2008).

- The Theory of Planned Behaviour (TPB) highlights the influence of social norms and perceived behavioural control, both of which are reinforced in structured programmes. (Ajzen, 2011).

These insights highlight the importance of embedding behavioural support strategies such as goal setting, social reinforcement, and structured monitoring into future strength training interventions for adults with Type 2 diabetes.

Table 9 Intervention type and frequency and duration of Enrolled Investigations

Study Reference	Population	Intervention Type	Frequency & Duration	QoL Instrument	Key Findings
Venkataraman et al. (2019)	Individuals with DPN	Strength & balance training, short term, small sample size	1 day/week, 8 weeks	SF-36	No significant QoL improvement; enhanced functional status.
Sisir et al. (2012)	Adults with T2DM	Supervised strength training, good adherence	3-5 days/week, 12 weeks	SF-36	Improved physical QoL; significant gains in muscular strength and bioimpedance phase angle.
Haleem et al. (2024)	Individuals with DPN	Strength & balance vs. aerobic, short term	3 days/week, 8 weeks	WHOQoL-BREF	Enhanced physical balance and neuropathy symptoms; limited emotional QoL improvement.
Al Ozairi et al. (2023)	Adults with T2DM	Home-based resistance training, structured,	3 days/week, 32 weeks	SF-36	Physical QoL improved, no significant mental health effects. Low adherence compared to supervised
Mager et al. (2021)	Adults with diabetes	Resistance & aerobic	3-5 days/week, 12 weeks	WHOQoL-BREF	Physical function improved, moderate mental health gains. Observational study with diverse exercise modality
Akinci et al. (2017)	Adults with T2DM	Videoconferencing-based RT	3 days/week, 8 weeks	EQ-5D	Improved physical function; no major impact on mental QoL. Remote intervention, low cost
Amaravadi et al. (2024)	Adults with T2DM	Structured strength & aerobic	3-5 days/week, 12 weeks	EQ-5D	Significant improvements in physical QoL; modest psychological effects, regular supervised.
Duncan et al. (2021)	Adults with T2DM	Long-term strength training	3-4 days/week, 24 weeks	SF-36	Sustained physical QoL improvements; limited mental health benefits.
Kobayashi et al. (2023)	Normal-weight adults with T2DM	Strength vs. aerobic	3-5 days/week, 9 months	SF-36	Strength training more effective for glycaemic control and body composition than aerobic training.
Sabag et al. (2023)	Diabetic individuals	Strength, aerobic, & combined	N/A	N/A	Combined training improved physical QoL; resistance training had mixed results.
Formica et al. (2023)	Older adults (mean age ~70)	Resistance & dietary changes	N/A	N/A	No significant impact on QoL; limited changes in physical and mental health outcomes.
Cai et al. (2017)	Adults with T2DM	Aerobic, resistance, combined	N/A	N/A	Aerobic exercise consistently improved QoL; resistance training showed mixed effects.

This systematic review evaluated the effectiveness of strength training programs on the quality of life (QoL) in adult diabetic patients. The studies reviewed included various strength training interventions, including home-based, supervised, and combined exercise programs, with differing frequencies and durations. The findings indicate that strength training has a positive effect on physical health QoL outcomes, while its impact on mental health QoL remains unclear.

Physical Health Outcomes

A significant body of research demonstrates that strength training programs lead to improvements in various physical health outcomes, such as muscular strength, functional capacity, and glycaemic control. For example, Sisir et al. (2012) reported significant improvements in physical QoL, muscular strength, and bioimpedance phase angle in individuals with Type 2 diabetes following a 12-week supervised resistance training program. Similarly, Amaravadi et al. (2024) found that a structured combination of strength and aerobic training led to improvements in physical QoL, further supporting the beneficial impact of strength training on physical health in diabetic patients.

Strength training is also shown to improve other health markers, such as balance and body composition. Kobayashi et al. (2023) found that strength training was more effective than aerobic exercise in improving glycemic control and body composition (specifically, lean mass increase and fat mass decrease) in individuals with normal-weight T2DM. Additionally, Venkataraman et al. (2019) demonstrated that strength and balance training improved functional status in individuals with diabetic peripheral neuropathy, even though no significant improvement in overall QoL was observed. These findings highlight the value of strength training in managing the physical aspects of diabetes and related complications, such as neuropathy.

The effectiveness of strength training in improving physical health was also noted in individuals with T2DM following long-term interventions. Duncan et al. (2021) reported sustained improvements in physical QoL and functional capacity after a 24-week strength training program, underlining the importance of prolonged interventions for achieving lasting physical benefits. This suggests that while shorter programs may yield immediate benefits in physical function, longer programs are necessary for sustained improvement in diabetic health markers.

Mental Health Outcomes

The impact of strength training on mental health QoL, however, presents a slightly different picture. While most studies reported limited or no significant improvements in mental health QoL, a few studies noted moderate benefits. For instance, Sisir et al. (2012) and Al Ozairi et al. (2023) found minimal improvements in psychological health, with no significant effects on emotional QoL despite notable physical health gains. Similarly, Akinci et al. (2017) and Haleem et al. (2024) observed limited improvements in mental health QoL, which could be attributed to the lack of comprehensive psychological measures or the brief duration of the interventions.

Interestingly, studies involving combined exercise modalities, such as resistance and aerobic exercise, reported more favourable mental health outcomes. Mager et al. (2021) found moderate improvements in mental health QoL following a combined resistance and aerobic exercise program, suggesting that combining strength training with other exercise types may enhance psychological well-being. Myres et al. (2013) also observed greater improvements in mental health QoL with combined exercise programs compared to strength training alone, reinforcing the idea that multimodal interventions may have more substantial psychological benefits than strength training on its own.

The inconsistency in mental health outcomes may be attributed to several factors, including differences in intervention duration, the nature of the exercise program, and the presence of support systems such as supervision or group exercise. While supervised exercise programs may provide social support and motivation that can enhance mental well-being, home-based programs, as seen in the study by Al Ozairi et al. (2023), had less impact on emotional QoL, suggesting that supervision and community support may play a crucial role in promoting psychological benefits.

Duration, Frequency, and Program Type

The duration and frequency of strength training programs appear to influence both physical and mental health outcomes. Studies such as those by Duncan et al. (2021), which used a 24-week intervention, reported sustained improvements in physical QoL but no significant impact on mental health. Conversely, shorter interventions, such as those by Venkataraman et al. (2019), which lasted only 8 weeks, reported no improvements in either physical or mental QoL. This suggests that longer durations may be necessary to achieve meaningful physical health improvements but may not necessarily translate into enhanced mental health benefits.

Home-based strength programs, such as those studied by Al Ozairi et al. (2023), resulted in physical improvements but had limited effects on mental health. The lack of direct supervision and social interaction in home-based programs may contribute to this lack of psychological benefit. In contrast, supervised programs, including those that involve group sessions or videoconferencing (Akinci et al., 2017), may offer additional psychological advantages through the provision of support and motivation.

Implications for Practice

The findings of this review suggest that strength training is an effective intervention for improving physical health outcomes of quality of life in adult T2DM patients, particularly in terms of muscular strength, functional capacity, and glycaemic control. These physical benefits are crucial for managing diabetes and its complications. However, the impact of strength training on mental health QoL remains limited and inconsistent across studies, suggesting that strength training alone may not be sufficient to improve psychological well-being in T2DM patients.

Clinicians and exercise professionals may consider combining strength training with other forms of exercise, such as aerobic or balance training, to achieve more comprehensive benefits for both physical and mental health. Furthermore, the inclusion of supervised sessions, where possible, could enhance social support and psychological motivation, potentially improving both physical and mental health outcomes.

Limitations and Future Research

While strength training programs demonstrate clear benefits for physical health in T2DM patients, the mixed results regarding mental health outcomes point to the need for further research. Future studies should aim to explore the psychological effects of strength training in more depth, using robust mental health measures and considering the role of social support in intervention outcomes. Additionally, more research is needed to investigate the optimal combination of strength training with other types of exercise and to determine the ideal duration and frequency of interventions to maximize both physical and mental health outcomes in T2DM patients.

Conclusion of results

In conclusion, strength training is effective in improving physical health outcomes in adult T2DM patients, including muscular strength, functional capacity, and glycemic control. However, its impact on mental health QoL is less clear, with some studies showing limited or no improvements and some studies reported reduction in depression, anxiety, and diabetes specific distress. This inconsistency highlights the need for future research which should focus on understanding the psychological benefits of strength training and exploring multimodal exercise programs that combine strength training with other forms of exercise to optimize the benefits for diabetic populations. Adherence emerged as a critical determinant of effectiveness. Supervised programmes, which provided professional oversight and social support, consistently achieved higher adherence rates and greater improvements in QoL than home-based or unsupervised programmes. This emphasizes the importance of integrating behavioural support strategies into intervention design.

These results highlight the need for physiotherapists to design multimodal programs that combine strength training with aerobic or balance exercises, delivered in supervised or group-based contexts. Such approaches may optimize both physical and psychological health outcomes in d people with diabetes.

While this systematic review provides valuable insights into the effectiveness of strength training programs on the quality of life of adult diabetic patients, the limitations highlighted suggest areas for further research. Future studies should focus on standardizing QoL measures, assessing mental health outcomes more thoroughly, and

exploring the long-term effects of strength training. Addressing the psychological, motivational, and adherence-related gaps will be essential for maximising its impact on overall quality of life and these limitations will enhance our understanding of how strength training can best be utilized to improve both physical and mental health in patients with T2DM.

Chapter 5 Discussion

5.1 Introduction

The increasing incidence of Type 2 diabetes mellitus (T2DM) among adults requires effective interventions for improving patient outcomes, especially in quality of life, to address both physical and psychological consequences of the disease. This research aims to compare the effectiveness of different strength training programs in improving QoL in adults aged 18 or older and diagnosed with T2DM. The findings highlight the importance of strength training strategies in enhancing physical and psychological health and supporting overall quality of life. While pharmacological management remains central to care, lifestyle interventions, particularly exercise, are increasingly recognised as critical to long term disease management.

Strength training has emerged as a promising modality, not only for its effects on metabolic control but also for its potential to enhance quality of life (QoL). This chapter discusses the findings of current review in relations to existing literature, with a focus on the effectiveness of structured and unstructured strength training programs, their impact on QoL, and the recommended strategies for implementation.

5.2 Effectiveness of strength training program

The strength training program includes both structured and unstructured programs and has shown significant results for individuals with T2DM. Structured strength training which involves a planned regimen with specific exercises, sets and repetitions which is supervised by a fitness trainer demonstrated significant improvements in muscle strength, glycaemic control, and insulin sensitivity (Qadir et al., 2021). Whereas an unstructured program includes activities such as body weight exercise and gardening which are less formalized but still promote better muscle strength and metabolic outcomes (Terauchi et al., 2021**)**.

A research study indicates that a structured strength training program leads to improvement in muscle mass, sensitivity to insulin and glycemic control in T2DM. For example, a meta-analysis showcased that participants who are engaged in structured

resistance training have a reduction in HbA1c levels when compared to those who did not participate in such programs. This reduction in levels is one of the keys indicating factors in long-term glycemic control and is linked with reduced complications from diabetes (Qadir et al., 2021). These findings support those of this study, where structured interventions demonstrated superior benefits for managing diabetes complications.

Whereas unstructured training programs including strength-building elements in daily life can increase adherence and enjoyment and are vital for long-term engagement. For example, there are studies which have shown that the incorporation of resistance exercises into everyday life can lead to improvements in quality of life and physical function without the need for formal gym training. Thus, both structured and unstructured programs have advantages that can be used based on individual preferences and circumstances (Hughes et al., 2017).

5.3 Impact on Quality of Life

The impact of strength training on the quality of life of adults with T2DM is multifactorial. Improvement in physical health outcomes is directly correlated with enhanced psychological well-being. Strength training is also associated with reduced symptoms of depression and anxiety. These symptoms are very common among individuals managing chronic conditions like diabetes. The empowerment acquired from increased physical capability can create a positive self-image and improve control of an individual's health (Myers et al., 2013).

Additionally, the social aspect of participating in group-based strength training can enhance the quality of life further. Social interactions during these exercise sessions can also reduce feelings of stress, and isolation and further improve overall emotional health. Programs which encourage peer support not only help in motivating participants but also generate a sense of belonging which is necessary for sustained engagement in physical activity (Myers et al., 2013). These improvements can be measured using validated QoL instruments such as the SF-36 and WHOQOL-BREF, which capture both physical and mental health domains.

5.4 Strength Training Programs for Patients with T2DM

The discussion below highlights the specific strength training programs which are recommended for individuals with T2DM focusing on the effectiveness and practical implementation of these programs.

Structured Resistance Training

Structured resistance training involves a systematic approach to exercise which includes predefined steps, repetitions and rest periods and are usually facilitated by a trained instructor. They are highly recommended for individuals suffering from T2DM. A study by Boule (2017) showed that individuals engaging in structured resistance training experience reductions in HbA1c levels indicating improved glycemic control. These programs can enhance muscle strength and insulin sensitivity, making them beneficial for the management of diabetes related complications.

Combination of Resistance and Aerobic Training

A systematic review suggests that a combination of aerobic and resistance training programs can lower blood glucose levels and improve the metabolic health of an individual. The combination of walking and cycling with strength training enhances cardiovascular fitness and builds muscle. The findings of this study also noted that combined aerobic and resistance programs, such as those reported by Al-Mhanna et al. (2024), provide additional cardiometabolic benefits beyond resistance training alone.

Unstructured Resistance Training

Research indicates that unstructured activities can lead to improvement in adherence due to flexibility and their integration into daily life. As reported by Hughs et al. (2017), lifestyle-based activities are particularly effective for individuals who face barriers to structured programs.

Furthermore, a study suggests that participants who integrate physical activities into their daily routines have better satisfaction and engagement rates when compared with

the ones who don't (Abusleme-Allimant et al., 2023). This study highlighted that such approaches yield moderate but meaningful benefits for QoL and daily functioning.

Aquatic Resistance Training

The aquatic exercise routines are another option for individuals with Type 2 diabetes mellitus, especially for those who are having joint pain or associated mobility issues. Underwater treadmill exercises combine the elements of aerobic and resistance training in low-impact environments making it a suitable option for a wide range of fitness levels (Conners et al., 2018).

Adherence to Strategies

A major issue of strength training for individuals suffering from Type 2 diabetes mellitus is the adherence to treatment strategies. The factors influencing adherence include motivation, social support, accessibility and certain barriers to exercise. For improving adherence to structured training programs, it is vital to implement strategies that address these factors. These strategies may include personalized training programs. By designing strength training programs to meet an individual's needs, preferences and capabilities can help improve adherence rates. When considering participant interests and physical limitations, this personalization of programs is likely to be sustained by the participant over time. To empower patients by providing education about the advantages of strength training for the management of Type 2 diabetes mellitus, enhances adherence. Workshop sessions that are led by healthcare professionals can help increase the understanding of resistance training concepts and can thereby foster a supportive environment for the participants in the program. The use of behavioural frameworks (e.g., Self-Determination Theory and Health Belief Model) can also improve adherence rate. (Williams et al., 2009).

Using and incorporating technology such as fitness-based apps and wearable devices can help with adherence rates by allowing participants to track their progress and set realistic goals. There are studies which have shown that individuals who use technology for monitoring their physical activity are more likely to adhere to exercise regimens (Cartagena et al., 2021).

Summary of key findings

The evidence reviewed in this study indicates that structured strength training produces the most robust and consistent improvements in both physiological and psychological outcomes for adults with T2DM. Meta-analyses and controlled trials, such as those conducted by Boulé (2017) and Qadir et al. (2021), demonstrate significant reductions in HbA1c and enhanced insulin sensitivity. Combination programs provide additional cardiovascular benefits, while unstructured and aquatic interventions improve accessibility and engagement.

Importantly, the findings of this study revealed that psychological well-being is enhanced through improved self-efficacy, reduced depressive symptoms, and the social benefits of group-based participation. Adherence remains a central challenge, but strategies involving personalised support, behavioural frameworks, and technological tools demonstrate promise in sustaining long-term participation.

Overall, strength training represents a highly effective intervention for improving QoL in adults with T2DM, with structured programs offering the greatest clinical benefits while alternative approaches address issues of accessibility and adherence.

Chapter 6: Conclusions and Recommendations

Overview

The systematic review on the effectiveness of strength training programs to improve the quality of life in adults with Type 2 diabetes presents many findings that highlight the different benefits of these strategies. This conclusion includes the key information obtained from the research focusing on the importance of tailored strength training programs, dietary restrictions, and requirements for supportive environments to optimize health outcomes in this population. Evidence from both structured and unstructured programs indicates consistent benefits for physical health, glycaemic control and functional ability. (Myers et al., 2013; Mager et al., 2021; Al Qazairi et al., 2023; Jia et al., 2024; Sabag et al., 2023). However structured interventions appear to provide greater improvements in muscle strength, metabolic outcomes, and QoL, (Venkataraman et al., 2019; Sisir et al., 2019; Haleem et al., 2024), while unstructured lifestyle integrated approaches enhance adherence and long-term engagement. (Ranasinghe et al., 2018; Formica et al., 2023).

Structured programs tended to produce larger and more consistent effect where frequency, intensity, and progression were explicitly prescribed and monitored.

Value of Personalisation

An important finding from the research suggests the necessity of personalised strength training programs. The effectiveness of these strategies varies based on individual factors like gender, age, comorbidities and personal choices (Jia et al., 2024). For example, young adults may thrive in high-intensity environments while old adults may need low-impact exercises which focus on balance and flexibility. Therefore, understanding these differences is vital for designing an effective training program which will not only fulfil the health goals but will also support long term adherence and sustained psychological well-being.

Diet Considerations

The integration of dietary management with strength training is seen as an essential factor influencing health outcomes. Evidence from the literature highlights that diet plays a crucial role in diabetes management accounting for substantial proportion of

overall health outcomes when combined with exercise. A well-structured diet program which is tailored to an individual's requirements can enhance the effectiveness of strength training by facilitating better recovery and higher energy levels. The findings further suggest that patients who adhere to dietary guidelines and strength training programs experience more improvement in their quality of life when compared to those who focus on exercise alone (Cai et al., 2017).

To summarise combining structured diet programs with resistance training:

- Improves recovery and energy levels.
- Enhances adherence to treatment.
- Leads to greater improvements in QoL compared to exercise alone.

Thus, holistic interventions incorporating both diet and exercise are recommended.

Barriers to Implementation

Despite clear benefits, several barriers limit participation in strength training:

- Practical barriers: time constraints, limited access to facilities or equipment.
- Psychological barriers: fear of injury, lack of motivation.
- Social barriers: insufficient encouragement from family or healthcare providers.

Social support networks have been shown to play a crucial role in adherence, with patients encouraged by peers or professionals being more likely to maintain long-term participation (Ranasinghe et al., 2018; Akinci et al., 2018).

Recommendations for Strength Training Integration

To maximise adherence and outcomes, the following strategies are recommended:

1. Education & Awareness: Workshops and patient sessions highlighting the benefits of strength training. Increasing awareness can empower patients to adopt exercise as a sustainable component of diabetes management.
2. Personalised Programs: Exercise prescription should be tailored to health status, fitness levels, and individual needs. This ensures safety, maximises efficacy and accommodates diverse patient needs.
3. Group Engagement: Community-based or group training to enhance motivation and accountability, and adherence. This has been shown to improve long term participation and enjoyment of physical activity.

4. Monitoring & Feedback: Regular assessment of progress and adjustments based on fitness outcomes. Ongoing monitoring enables clinicians to adjust exercise intensity and volume based on fitness outcomes and patient response, thereby ensuring continuous improvement.
5. Holistic Care: Integration of exercise with dietary management and behavioural support. This optimises overall quality of life and long-term health outcomes.

Limitations of study

This review is limited by:

- Restriction to studies published after 2012 and up to June 2024, potentially overlooking earlier research before January 2012 and research published after June 2024.
- Variability in study design and outcome measures, complicating direct comparisons.
- Reliance on self-reported QoL measures, which may introduce bias.

These limitations highlight the need for more standardised methodologies and outcome measures in future research.

Future Research Directions

To strengthen the evidence base, future research should:

- Employ longitudinal designs to assess the sustainability of benefits.
- Use mixed-methods approaches to capture both quantitative outcomes (e.g., HbA1c, muscle strength) and qualitative insights (e.g., patient motivation, barriers).
- Focus on diverse and underserved populations (older adults, rural communities, individuals with multiple comorbidities).
- Evaluate the psychological benefits of strength training, such as stress reduction and improved emotional well-being.

Clinical Recommendations

The findings of this review highlight several important clinical recommendations for integrating strength training into the management of T2DM. Firstly, healthcare providers should include strength training within standard diabetes care pathways to

ensure it becomes a routine component of disease management. Exercise prescriptions should be tailored to individual characteristics, including age, comorbidities, functional capacity, and personal preferences, thereby promoting adherence and safety. Short-term supervised initiation is recommended to reduce fear of injury, enhance exercise technique, and build patient confidence before transitioning to independent or community-based programs. Community and group training models are particularly valuable, as they foster motivation, social connectedness, and long-term sustainability. Furthermore, aligning strength training with dietary counselling is essential to maximise health outcomes, since combined interventions have been shown to produce superior benefits compared to exercise alone. Finally, clinicians should monitor a broad range of outcomes, extending beyond glycaemic control to include physical, social, and psychological domains of quality of life, ensuring a more holistic evaluation of intervention effectiveness.

Conclusion

Strength training is a safe, feasible, and effective adjunct to routine medical management for adults with T2DM when programs are individualised, supported, and coupled with dietary guidance. Structured formats maximise consistency and magnitude of benefit, while unstructured, lifestyle-integrated approaches may enhance reach and long-term engagement. Health systems should prioritise scalable, hybrid models that preserve commitment where it matters and flexibility where it helps people sustain activity. Done well, these approaches can meaningfully improve quality of life, empower self-management, and reduce the burden of T2DM at individual and population levels.

References

Abusleme-Allimant, R., Hurtado-Almonacid, J., Reyes-Amigo, T., Yáñez-Sepúlveda, R., Cortés-Roco, G., Arroyo-Jofré, P., & Páez-Herrera, J. (2023). Effects of structured and unstructured physical activity on gross motor skills in preschool students to promote sustainability in the physical education classroom. *Sustainability*, 15(13), 10167. https://doi.org/10.3390/su151310167

Ajzen, I. (2011). The theory of Al-Khaledi, M., Al-Ali, N., Al-Shatti, A., Al-Mousawi, T., Al-Taiar, A., & Al-Mahdi, M. (2018). Diabetes self-management: A study of knowledge, attitudes, and practices among patients with type 2 diabetes in Kuwait. Diabetes & Metabolic Syndrome: *Clinical Research & Reviews, 12*(1), 9–13. https://doi.org/10.1016/j.dsx.2017.08.004.

Akinci, B., Yeldan, I., Satman, I., Dirican, A., & Ozdincler, A. R. (2018). The effects of internet-based exercise compared with supervised group exercise in people with type 2 diabetes: A randomized controlled study. *Diabetes Therapy*, *9*(2), 685-696. https://doi.org/10.1007/s13300-018-0398-3

Al-Mhanna, S. B., Batrakoulis, A., Ghazali, W. S. W., Mohamed, M., Aldayel, A., Alhussain, M. H., Afolabi, H. A., Wada, Y., Gülü, M., Elkholi, S., Abubakar, B. D., & Rojas-Valverde, D. (2024). Effects of combined aerobic and resistance training on glycemic control, blood pressure, inflammation, cardiorespiratory fitness, and quality of life in patients with type 2 diabetes and overweight/obesity: A systematic review and meta-analysis. PeerJ, 12, e17525. https://doi.org/10.7717/peerj.17525

Alamri, W., Alhofaian, A., & Mersal, N. (2021). Quality of life (QoL) among health care workers with diabetes mellitus: A literature review. *Clinical Practice*, *11*(4), 801-826. https://doi.org/10.3390/clinpract11040096

Alharahsheh, H. H., & Pius, A. (2020). A review of key paradigms: Positivism vs. interpretivism. *Global Academic Journal of Humanities and Social Sciences*, *2*(3), 39-43. https://doi.org/10.47310/gajhss.2020.v02i03.005

Al Ozairi, E., Alsaeed, D., Al Roudhan, D., Jalali, M., Mashankar, A., & Taliping, D. (2023). The effect of home-based resistance exercise training in people with type 2 diabetes: A randomized controlled trial. *Diabetes & Metabolism*, *49*(2), 145-157. https://doi.org/10.1016/j.diabet.2023.02.001

American Diabetes Association. (2020). Standards of medical care in diabetes—2020. *Diabetes Care*, *43*(Suppl. 1), S1–S212. https://doi.org/10.2337/dc20-Sint

Amaravadi, S. K., Maiya, G. A., Kamath, V., & Shastry, B. A. (2024). Effectiveness of structured exercise program on insulin resistance and quality of life in type 2 diabetes mellitus: A randomized controlled trial. *PLoS ONE*, *19*(5), e0302831. https://doi.org/10.1371/journal.pone.0302831

Barreira, E., Novo, A., Vaz, J. A., & Pereira, A. M. G. (2018). Dietary program and physical activity impact on biochemical markers in patients with type 2 diabetes: A systematic review. *Atencion Primaria*, *50*(10), 590–610. https://doi.org/10.1016/j.aprim.2017.06.012

Bassi, D., Mendes, R. G., Arakelian, V. M., Caruso, F. C. R., Cabiddu, R., & Junior, J. C. B. (2016). Potential effects on cardiorespiratory and metabolic status after a concurrent strength and endurance training program in diabetes patients: A randomized controlled trial. *Diabetes Research and Clinical Practice*, *122*, 110-121. https://doi.org/10.1016/j.diabres.2016.09.003

Boachie, M. K., Thsehla, E., Immurana, M., Kohli-Lynch, C., & Hofman, K. J. (2022). Estimating the healthcare cost of overweight and obesity in South Africa. *Global Health Action, 15*(1), 2045092. https://doi.org/10.1080/16549716.2022.2045092

Brandt, H., Henninger, M., Ulitzsch, E., Kleinke, K., & Schäfer, T. (2024). Responsible research assessment in the area of quantitative methods research: A comment on Gärtner et al. *Meta-Psychology, 8*. https://doi.org/10.15626/MP.2023.3796

Canli, U., & Aldhahi, M. I. (2024). The physiological and physical benefits of two types of concurrent training: A randomised controlled trial. BMC *Sports Science, Medicine & Rehabilitation, 16*, 1-10. https://doi.org/10.1186/s13102-023-00798-x

Cai, H., Li, G., Zhang, P., Xu, D., & Chen, L. (2016). Effect of exercise on the quality of life in type 2 diabetes mellitus: A systematic review. *Quality of Life Research, 26*(3), 515–530. https://doi.org/10.1007/s11136-016-1481-5

Cartagena, M. V., Tort-Nasarre, G., & Arnaldo, E. R. (2021). Barriers and facilitators for physical activity in adults with type 2 diabetes mellitus: A scoping review. *International Journal of Environmental Research and Public Health, 18*(10), 5359. https://doi.org/10.3390/ijerph18105359

Cavan, D. A., & Harris, K. M. (2015). *The burden of diabetes. Diabetes Research and Clinical Practice, 108*(1), 36-45. https://doi.org/10.1016/j.diabres.2015.02.018

Colagiuri, S., Dickinson, J., & Kesson, C. (2013). The role of lifestyle intervention in the management of type 2 diabetes. *The Medical Journal of Australia, 199*(9), 10-14. https://www.mja.com.au/journal/2013/199/9/role-lifestyle-intervention-management-type-2-diabetes

Conners, R. T., Caputo, J. L., Coons, J. M., Fuller, D. K., & Morgan, D. W. (2018). Impact of underwater treadmill training on glycemic control, blood lipids, and health-related fitness in adults with type 2 diabetes. *Clinical Diabetes, 37*(1), 36–43. https://doi.org/10.2337/cd17-0066

Dela, F., Ingersen, A., Andersen, N. B., Nielsen, M. B., Petersen, H. H. H., Hansen, C. N., Larsen, S., Wojtaszewski, J., & Helge, J. W. (2019). Effects of one-legged high-intensity interval training on insulin-mediated skeletal muscle glucose homeostasis in patients with type 2 diabetes. *Acta Physiologica, 226*(2), e13245. https://doi.org/10.1111/apha.13245

Fadare, J., Gbadegesin, B., & Olamoyegun, M. (2015). Medication adherence and direct treatment cost among diabetes patients attending a tertiary healthcare facility in Ogbomosho, Nigeria. *Malawi Medical Journal, 27*(2), 65. https://doi.org/10.4314/mmj.v27i2.7

Formica, M. B., Gianoudis, J., Nowson, C. A., O'Connell, S. L., Milte, C., Ellis, K. A., & Daly, R. M. (2023). Effects of a multi-component, resistance-based exercise program combined with additional lean red meat on health-related quality of life in older adults: Secondary analysis of a 6-month randomized controlled trial. The *Journal of Nutrition, Health & Aging, 27*(6), 421–429. https://doi.org/10.1007/s12603-023-1915-1

García-Hermoso, A., Ramos-Campo, D. J., & Martínez-Vizcaíno, V. (2020). Resistance training and glycemic control in adults with type 2 diabetes: A systematic review and meta-analysis. *BMJ Open Diabetes Research & Care, 8*(1), e001552. https://doi.org/10.1136/bmjdrc-2020-001552

Guh, D. P., Zhang, W., Bansback, N., Amarsi, Z., Birmingham, C. L., & Anis, A. H. (2009). The incidence of co-morbidities related to obesity and overweight: A systematic review and meta-analysis. *BMC Public Health*, 9, Article 88 https://doi.org/10.1186/1471-2458-9-8.

Jia, J., Xue, Y., Zhang, Y. C., Hu, Y., & Liu, S. (2024). The effects of resistance exercise interventions on quality of life and glycemic control in patients with type 2 diabetes: Systematic review and meta-analysis of randomized controlled trials. *Primary Care Diabetes, 18*(2), 119–125. https://doi.org/10.1016/j.pcd.2023.12.006

Haleem, F., Saeed, A., Kundi, M., Jalal, A., Bilal, M., & Jalal, M. (2024). Combined effects of strength and balance training versus aerobic training on balance, neuropathy symptoms, and quality of life in patients with diabetic peripheral neuropathy. *Diabetes Therapy, 15*(2), 1–12. https://doi.org/10.1007/s13300-024-01567-4

Hamidi, S., Gholamnezhad, Z., Kasraie, N., & Sahebkar, A. (2022). The effects of self-efficacy and physical activity improving methods on the quality of life in patients with diabetes: A systematic review. *Journal of Diabetes Research, 2022*, Article 2884933. https://doi.org/10.1155/2022/2884933

Hernandez-Tejada, M. A., Lynch, C. P., Strom, J. L., & Egede, L. E. (2012). Effect of perceived control on quality of life in indigent adults with type 2 diabetes. *The Diabetes Educator, 38*(2), 256-262. https://doi.org/10.1177/0145721711436135

Hughes, D. C., Ellefsen, S., & Baar, K. (2017). Adaptations to endurance and strength training. *Cold Spring Harbor Perspectives in Medicine, 8*(6), a029769. https://doi.org/10.1101/cshperspect.a029769

Kelley, G. A., & Kelley, K. S. (2017). Exercise and quality of life in older adults with type 2 diabetes: A systematic review. *Diabetes Spectrum, 30*(4), 217-222. https://doi.org/10.1177/0145445517738274

Kobayashi, Y., Long, J., Dan, S., Johannsen, N. M., Talamoa, R., Raghuram, S., Chung, S., Kent, K., Basina, M., Lamendola, C., Haddad, F., Leonard, M. B., Church, T. S., & Palaniappan, L. (2023). Strength training is more effective than aerobic exercise for improving glycaemic control and body composition in people with normal-weight type 2 diabetes: A randomized controlled trial. *Diabetologia, 66*(10), 1897–1907. https://doi.org/10.1007/s00125-023-05958-9

Kanaley, J. A., Colberg, S. R., Corcoran, M. H., Malin, S. K., Rodriguez, N. R., Crespo, C. J., Kirwan, J. P., & Zierath, J. R. (2022). Exercise/physical activity in individuals with type 2 diabetes: A consensus statement from the American College of Sports Medicine. *Medicine & Science in Sports & Exercise, 54*(2), 353–368. https://doi.org/10.1249/mss.0000000000002800

Kemps, H., Kränkel, N., Dörr, M., Moholdt, T., Wilhelm, M., Paneni, F., Serratosa, L., Ekker Solberg, E., Hansen, D., Halle, M., & Guazzi, M. (2019). Exercise training for patients with type 2 diabetes and cardiovascular disease: What to pursue and how to do it. A position paper of the European Association of Preventive Cardiology (EAPC). *European Journal of Preventive Cardiology, 26*(7), 709–727. https://doi.org/10.1177/2047487318820420

Kretschmann, R. (2023). Effects of an 8-week after-school resistance program in secondary school students. *Journal of Physical Education and Sport, 23*(6), 1376-1384. https://doi.org/10.7752/jpes.2023.06168

Lascar, N., Brown, J., Pattison, H., Barnett, A. H., Bailey, C. J., & Bellary, S. (2018). Type 2 diabetes in adolescents and young adults. *The Lancet Diabetes & Endocrinology, 6*(1), 69–80. https://doi.org/10.1016/s2213-8587(17)30186-9

Lewis, B. A., Schuver, K., & Dunsiger, S. (2023). Evaluating the feasibility and efficacy of a home-based combined high-intensity interval and moderate-intensity training program for increasing physical activity among low-active adults: A randomised pilot trial. *PLoS ONE, 18*(2), e0281985. https://doi.org/10.1371/journal.pone.0281985

Liou, S., Ching-Yu, C., Tsui-Ping Chu, Chia-Hao, C., & Hsiu-Chen, L. (2023). Effectiveness of differentiated instruction on learning outcomes and learning satisfaction in the evidence-based nursing course: Empirical research quantitative. *Nursing Open, 10*(10), 6794-6807. https://doi.org/10.1002/nop2.1926

Longo, M., Bellastella, G., Maiorino, M. I., Meier, J. J., Esposito, K., & Giugliano, D. (2019). Diabetes and aging: From treatment goals to pharmacologic therapy. *Frontiers in Endocrinology, 10*, 45. https://doi.org/10.3389/fendo.2019.00045

Mao, J., Wang, T., Wang, Y., & Kuan, G. (2023). Effect of resistance training programs differing in set structure on muscular hypertrophy and performance in untrained young men. *Frontiers in Physiology, 14*. https://doi.org/10.3389/fphys.2023.1301535

Mengistu, W., Soromessa, T., & Legese, G. (2020). Method for conducting systematic literature review and meta-analysis for environmental science research. *MethodsX, 7*, 100777. https://doi.org/10.1016/j.mex.2020.100777

Merchant, R. A., Soong, J. T. Y., & Morley, J. E. (2022). Gender differences in body composition in pre-frail older adults with diabetes mellitus. *Frontiers in Endocrinology, 13,* 795594. https://doi.org/10.3389/fendo.2022.795594

Miller, T. A., & DiMatteo, M. R. (2013). Importance of family/social support and its impact on treatment adherence in people with diabetes mellitus: A review. *Diabetes,*

Metabolic Syndrome and Obesity: Targets and Therapy, 6, 421–426. https://doi.org/10.2147/DMSO.S36368

Mishra, V., Nayak, P., Sharma, M., Alberti, A., Alwashmi, A., Aljasir, M. A., Alsowayeh, N., & Tambuwala, M. M. (2021). Emerging treatment strategies for diabetes mellitus and associated complications: An update. *Pharmaceutics, 13*(10), 1568. https://doi.org/10.3390/pharmaceutics13101568

Mokhele, S., & Mokhele, T. (2024). Prevalence and determinants of household self-reported diabetes mellitus in Gauteng, South Africa. *International Journal of Environmental Research and Public Health, 21*(11), 1537.

Mutyambizi, C., Booysen, F., Hongoro, C., Pavlova, M., & Groot, W. (2019). Incidence, socioeconomic inequalities, and determinants of catastrophic health expenditure and impoverishment for diabetes care in South Africa: A study at two public hospitals in Tshwane. *International Journal for Equity in Health, 18*(1). https://doi.org/10.1186/s12939-019-0977-3

Myers, V. H., McVay, M. A., Brashear, M. M., Johannsen, N. M., Swift, D. L., Kramer, K., Harris, M. N., Johnson, W. D., Earnest, C. P., & Church, T. S. (2013). Exercise training and quality of life in individuals with type 2 diabetes: A randomized controlled trial. *Diabetes Care, 36*(7), 1884–1890. https://doi.org/10.2337/dc12-1153

Pan, B., Ge, L., Xun, Y., Chen, Y., Gao, C., Han, X., Zuo, L., Shan, H., Yang, K., Ding, G., & Tian, J. (2018). Exercise training modalities in patients with type 2 diabetes mellitus: A systematic review and network meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity, 15*(1). https://doi.org/10.1186/s12966-018-0703-3

Park, K.-Y., Hwang, H.-S., Cho, K.-H., Han, K., Nam, G. E., Kim, Y. H., Kwon, Y., & Park, Y.-G. (2019). Body weight fluctuation as a risk factor for type 2 diabetes: Results from a nationwide cohort study. *Journal of Clinical Medicine, 8*(7), 950. https://doi.org/10.3390/jcm8070950

Pradyumna, A., & Gundi, M. (2024). Reflections on the design and application of 'Surveypura': A simulation-based pedagogical tool for quantitative research methods in public health and social sciences. *Advances in Simulation, 9*, 1–8. https://doi.org/10.1186/s41077-023-00275-y

Rubin, R. R., & Peyrot, M. (1999). Quality of life and diabetes. *Diabetes/Metabolism Research and Reviews, 15*(3), 205–218. https://doi.org/10.1002/(SICI)1520-7560(199905/06)15:3<205:AID-DMRR29>3.0.CO;2

Qadir, R., Sculthorpe, N. F., Todd, T., & Brown, E. C. (2021). Effectiveness of resistance training and associated program characteristics in patients at risk for type 2 diabetes: A systematic review and meta-analysis. *Sports Medicine - Open, 7*(1), 1-15. https://doi.org/10.1186/s40798-021-00321-x

Qiu, S., Cai, X., Yin, H., Sun, Z., Zügel, M., Steinacker, J. M., & Schumann, U. (2018). Exercise training and endothelial function in patients with Type 2 diabetes: A meta-analysis. *Cardiovascular Diabetology, 17*(1). https://doi.org/10.1186/s12933-018-0711-2

Qiu, Y., Yi, Q., Li, S., Zhu, Z., Wang, Y., … et al. (2022). Transition of cardiometabolic status and the risk of type 2 diabetes mellitus among middle-aged and older Chinese: A national cohort study. *Journal of Diabetes Investigation, 13*(8), 1426-1437. https://doi.org/10.1111/jdi.13805

Rahimi, A., Hashemzadeh, M., Zare-Farashbandi, F., Alavi-Naeini, A., & Daei, A. (2019). Transtheoretical model of health behavioral change: A systematic review. *Iranian Journal of Nursing and Midwifery Research, 24*(2), 83–90. https://doi.org/10.4103/ijnmr.IJNMR_94_17

Ranasinghe, C., Hills, A. P., Constantine, G. R., Finlayson, G., Katulanda, P., & King, N. A. (2018). Study protocol: A randomized controlled trial of supervised resistance training versus aerobic training in Sri Lankan adults with type 2 diabetes mellitus: SL-DART study. *BMC Public Health, 18*, 5069. https://doi.org/10.1186/s12889-018-5069-6

Rawshani, A., Rawshani, A., Franzén, S., Sattar, N., Eliasson, B., Svensson, A.-M., Zethelius, B., Miftaraj, M., McGuire, D. K., Rosengren, A., & Gudbjörnsdottir, S. (2018). Risk factors, mortality, and cardiovascular outcomes in patients with type 2 diabetes. *New England Journal of Medicine, 379*(7), 633–644. https://doi.org/10.1056/nejmoa1800256

Sabag, A., Chang, C. R., François, M. E., Keating, S. E., Coombes, J. S., & Johnson, N. A. (2023). The effect of exercise on quality of life in type 2 diabetes: A systematic review and meta-analysis. *Medicine & Science in Sports & Exercise, 55*(8), 1353–1365. https://doi.org/10.1249/mss.0000000000003172

Sherifali, D., Pinto da Silva, L., Dewan, P., Cader, F. A., Dakhil, Z., Gyawali, B., Klassen, S., Fadhil Yaseen, I., Jovkovic, M., Khalid, S., Fitzpatrick-Lewis, D., Alliston, P., & Racey, M. (2024). Peer Support for Type 2 Diabetes Management to Reduce Morbidity and Mortality from Cardiovascular Disease in Low- and Middle-Income Countries (LMICs): A Scoping Review. *Global Heart, 19*(1), Article 20. https://doi.org/10.5334/gh.1299

Sinclair, J., Ageely, H., Mahfouz, M. S., Abdulrahman, A. H., Darraj, H., Solan, Y., Allan, R., Bahsan, F., Hafaf, H. A., Abohadash, A., Badedi, M., & Bottoms, L. (2023). Effects of a home-based physical activity program on blood biomarkers and health-related quality of life indices in Saudi Arabian type 2 diabetes mellitus patients: A randomized controlled trial. *Life, 13*(6), 1413. https://doi.org/10.3390/life13061413

Sisir, M. F., Raja Azidin, R. M. F., Hasan, H., Abdul Ghani, R., Omar, M., & Ismail, H. (2019). Effects of different volume of resistance training on bioimpedance phase angle, muscular strength, and quality of life among diabetes patients. Journal of *Diabetes Research & Clinical Practice, 12*(3), 455–470. https://doi.org/10.1016/j.diabres.2019.12.008

Statista. (2024). Estimated number of diabetics worldwide 2021. Retrieved from https://www.statista.com/statistics/271442/number-of-diabetics-worldwide

Stonerock, G. L., Hoffman, B. M., Smith, P. J., & Blumenthal, J. A. (2015). Exercise as treatment for anxiety: Systematic review and analysis. *Annals of Behavioral Medicine, 49*(4), 542–556.https://doi.org/10.1007/s12160-014-9685-9

Tarantino, S., Martina, P. C., Papetti, L., Monte, G., Michela Ada, N. F., & Valeriani, M. (2024). Parental experiences in paediatric multiple sclerosis: Insights from quantitative research. *Children, 11*(1), 71. https://doi.org/10.3390/children11010071

Terauchi, Y., Takada, T., & Yoshida, S. (2021). A randomized controlled trial of a structured program combining aerobic and resistance exercise for adults with type 2 diabetes in Japan. *Diabetology International, 13*(1), 75–84. https://doi.org/10.1007/s13340-021-00506-5

Valverde, D. (2024). Effects of combined aerobic and resistance training on glycemic control, blood pressure, inflammation, cardiorespiratory fitness, and quality of life in patients with type 2 diabetes and overweight/obesity: A systematic review and meta-analysis. *PeerJ, 12*, e17525. https://doi.org/10.7717/peerj.17525

Veiga, D., Peralta, M., Gouveia, É. R., Carvalho, L., Encantado, J., Teixeira, P. J., & Marques, A. (2024). Moderating effect of grip strength in the association between diabetes mellitus and depressive symptomatology. *Sports, 12*(1), 3. https://doi.org/10.3390/sports12010003

Way, K. L., Thomas, H. J., Parker, L., Maiorana, A., Keske, M. A., Scott, D., Reed, J. L., Tieng, J., Hackett, D., Hawkins, T., Latella, C., Cordina, R., & Tran, D. L. (2023). Cluster sets to prescribe interval resistance training: A potential method to optimise resistance training safety, feasibility, and efficacy in cardiac patients. *Sports Medicine - Open, 9*(1), 86. https://doi.org/10.1186/s40798-023-00634-z

Williams, G. C., Patrick, H., Niemiec, C. P., Williams, L. K., Divine, G., Lafata, J. E., Heisler, M., & Tunceli, K. (2009). Reducing the health risks of diabetes: How self-determination theory may help improve medication adherence and quality of life. *The Diabetes Educator, 35*(3), 484–492. https://doi.org/10.1177/0145721709333856

World Health Organization. (2023). Diabetes. Retrieved from https://www.who.int/news-room/fact-sheets/detail/diabetes

World Health Organization. (2024). Urgent action needed as global diabetes cases increase four-fold over past decades. Retrieved from https://www.who.int/news/item/13-11-2024-urgent-action-needed-as-global-diabetes-cases-increase-four-fold-over-past-decades

Yang, D., Yang, Y., Li, Y., & Han, R. (2019). Physical exercise as therapy for type 2 diabetes mellitus: From mechanism to orientation. *Annals of Nutrition and Metabolism, 74*(4), 313–321. https://doi.org/10.1159/000500110

Zhang, Y., Pan, X.-F., Chen, J., Xia, L., Cao, A., Zhang, Y., Wang, J., Li, H., Yang, K., Guo, K., He, M., & Pan, A. (2019). Combined lifestyle factors and risk of incident type 2 diabetes and prognosis among individuals with type 2 diabetes: A systematic review and meta-analysis of prospective cohort studies. *Diabetologia, 63*(1), 49-65. https://doi.org/10.1007/s00125-019-04985-9

Zimmet, P., Alberti, K. G. M. M., & Shaw, J. (2001). Global and societal implications of the diabetes epidemic. *Nature, 414*(6865), 782-787. https://doi.org/10.1038/414782a

Appendix

Appendix A

Plagiarism Declaration

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I U. Ramlakan Narandas (Student number: 0006415D) am a student registered for the degree of MSc Physiotherapy in the academic year 2025.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature: Ulaysha Narandas Date: 02-April-25

Appendix B
Turnitin Report Summary

ORIGINALITY REPORT

34%	23%	23%	20%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University of Witwatersrand Student Paper	10%
2	wiredspace.wits.ac.za Internet Source	1%
3	Yaser Mohammed Al-Worafi. "Handbook of Complementary, Alternative, and Integrative Medicine - Education, Practice and Research Volume 4: Disease Focused Efficacy and Safety Profiles: Cardiovascular, Endocrine, Respiratory, Gastrointestinal, Renal, Arthritis and Neurology Disorders", CRC Press, 2025 Publication	1%
4	www.wjgnet.com Internet Source	1%
5	www.malacards.org Internet Source	<1%
6	www.researchgate.net Internet Source	<1%
7	worldwidescience.org Internet Source	<1%
8	www.mdpi.com Internet Source	<1%
9	www.fisiologiadelejercicio.com Internet Source	<1%
10	M.B. Formica, J. Gianoudis, C.A. Nowson, S.L. O'Connell, C. Milte, K.A. Ellis, Robin M. Daly. "Effects of a Multi-component, Resistance- Based Exercise Program Combined with Additional Lean Red Meat on Health-Related Quality of Life in Older Adults: Secondary Analysis of a 6-Month Randomized Controlled Trial", The Journal of nutrition, health and aging, 2023	<1%

Appendix C

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Faculty of Science

Division of Postgraduate Academic Management

Acquiescence Form

Name of Candidate:		Ulaysha Ramlakan Narandas	
Person Number:		0006415D	
Degree:		MSc. Physiotherapy	
Supervisor/s:		Dr Natalie Benjamin-Damons / Dr Kganetso Sekome	
School:		University of Witwatersrand	
Title of Thesis/Dissertation/Research Report:		THE EFFECTIVENESS OF STRENGTH TRAINING PROGRAMS ON QUALITY OF LIFE IN ADULTS WITH TYPE 2 DIABETES: A SYSTEMATIC REVIEW	
Date of First Submission:		02-April-2025	
Please answer all questions by ticking the appropriate box		**YES**	**NO**
1	Has this thesis/ dissertation/ research report been submitted with the acquiescence of the Supervisor?	✓	
2	To the best of your knowledge are you able to verify that the candidate has acknowledged wherever any information used in the thesis or other work have been obtained by her or him while employed by, or working under the aegis of, any person or organisation other than the University or its associated institutions?	✓	
3	Did the research involve animal experimentation? If YES, please certify that clearance was obtained from the Animal Ethics Committee. **Clearance Number:**		✓
4	Did the research involve the use of human subjects? If YES, please certify that clearance was obtained from the relevant Ethics Committee. **Clearance Number:**		✓
5	Did the research involve using genetically modified organisms or substances? If YES, please certify that clearance was obtained from the relevant Biosafety Review Board. **Clearance Number:**		✓
6	**ORCID Number:**		

7	Turnitin originality report similarity index		%
8	**PhD only**: Have aspects of this PhD work been published after peer-review or has a manuscript been submitted for publication? If YES, please provide details here: If NO, a motivation letter from the supervisor is required if this requirement is not yet met at the stage of first submission. If no letter is submitted, then this will delay the examination process. Be aware that at least one publication or at least one submitted manuscript covering the PhD work is a **REQUIREMENT FOR QUALIFICATION**.		N/A

Name of Supervisor (1): __Dr Natalie Benjamin-Damons____ **Signature of Supervisor (1):** _____

Name of Supervisor (2): _Dr Kganetso Sekome___ **Signature of Supervisor (2):** _____

Name of Head of School/Designate: _____

Signature of Head of School/Designate: _____

Date: _____

Supervisor/s please note:

Submission of a supervisor's report

Once a candidate submits her/his thesis/dissertation/research report for examination to the faculty, the supervisor must submit a supervisor's report to the Faculty Registrar. The supervisor's report is not an examiner's report. It will be used by the Faculty Graduate Studies Committee for the quality assurance of supervision, and for insight into the relationship between the Supervisor's assessment and that of the examiners. This report will not be seen by the examiners, but if requested by the candidate, it will be given to the candidate along with the examiners' reports, once the examination process is complete.

Contact Details for Postgraduate Administration, Faculty of Science:

Email: science.msc@wits.ac.za **or** science.phd@wits.ac.za

Appendix D

First Submission of Doctor of Philosophy/ Master of Science for Examination

Name of Candidate:	Ulaysha Ramlakan Narandas
Person Number:	0006415D
Degree:	MSc. Physiotherapy
Supervisor / Co-Supervisor:	Dr Natalie Benjamin-Damons / Dr Kganetso Sekome
School:	University of Witwatersrand
Title of Thesis/Dissertation/ Research Report:	THE EFFECTIVENESS OF STRENGTH TRAINING PROGRAMS ON QUALITY OF LIFE IN ADULTS WITH TYPE 2 DIABETES: A SYSTEMATIC REVIEW

	Please answer all questions by ticking the appropriate box	**YES**	**NO**
1	Did the research involve animal experimentation? If YES, please certify that clearance was obtained from the Animal Ethics Committee. **Clearance Number:**		✓
2	Did the research involve the use of human subjects? If YES, please certify that clearance was obtained from the relevant Ethics Committee. **Clearance Number:**		✓
3	Did the research involve using genetically modified organisms or substances? If YES, please certify that clearance was obtained from the relevant Biosafety Review Board. **Clearance Number:**		✓
4	**ORCID Number:**		
5	Have aspects of the research been published or submitted for publication? If yes, please provide details. **PhD students please note**: If there are NO publications or a submitted manuscript at the stage of first submission, a motivation letter from the supervisor is required.		✓

	At least one publication or one submitted manuscript covering the PhD work is a **REQUIREMENT FOR QUALIFICATION**.		
6	Have aspects of the research been presented at a conference/workshop? If yes, please provide details.		✓

Candidate's Declaration:

i. I hereby submit my PhD Thesis/ MSc dissertation / MSc research report for examination. (Delete whichever is not applicable)

ii. I confirm that my signed declaration in terms of Rule G9.7 is included in each copy of the thesis/ dissertation/research report.

iii. I have checked all copies of my thesis/ dissertation / research report and declare that no pages are missing or poorly reproduced.

iv. I hereby submit an electronic version of my submission for examination.

Candidate's Signature: ___ *U. Narandas* _____ **Date:** ___01-04-2025_____

Please Note:

- **You will not graduate until all your fees have been paid in full.**
- **You are required to complete a postgraduate amendment form to change personal details and information pertaining to your submission e.g. changes to title.**
- **Your first submission must include an electronic version of thesis/dissertation/ research report in PDF format and an acquiescence form. Your supervisor will inform you if you need to submit bound copies.**
- **You are advised to contact the Faculty Office for final submission requirements.**

Contact Details for Postgraduate Administration, Faculty of Science:
Email: **science.msc@wits.ac.za or science.phd@wits.ac.za**

Appendix E

Search Strategy

A secondary search was executed using the identified keywords and index terms across all databases searched. Search terms included:
((“Resistance Training” [Mesh]) AND “Quality of Life” [Mesh]) AND “Diabetes Mellitus” [Mesh] Filters: Middle Aged: 18-64 years Sort by: Most Recent

PubMed
(T2DM OR "Type 2 Diabetes Mellitus" OR "Type 2 Diabetes") AND ("Strength training" OR "Resistance training" OR "Weight training" OR "Muscle strength") AND ("Quality of life" OR "Health-related quality of life" OR "Well-being" OR "QoL" OR "HRQoL")

Scopus
(TITLE-ABS-KEY("Type 2 Diabetes Mellitus" OR "Type 2 Diabetes" OR T2DM)) AND (TITLE-ABS-KEY("Strength training" OR "Resistance training" OR "Weight training" OR "Muscle strength")) AND (TITLE-ABS-KEY("Quality of life" OR "Health-related quality of life" OR "Well-being" OR QoL OR HRQoL))

Web of science
TS=("Type 2 Diabetes Mellitus" OR "Type 2 Diabetes" OR T2DM) AND TS=("Strength training" OR "Resistance training" OR "Weight training" OR "Muscle strength") AND TS=("Quality of life" OR "Health-related quality of life" OR "Well-being" OR QoL OR HRQoL)

Cochrane
("Strength Training" OR "Resistance Training" OR "Weight Training") AND ("Quality of Life" OR "Health-Related Quality of Life" OR "HRQoL") AND ("Diabetes Mellitus" OR "Type 2 Diabetes") AND ("Effectiveness" OR "Efficacy" OR "Outcomes") AND ("Adult" OR "Aged" OR "Middle-Aged")

EMBASE
('resistance training'/exp OR 'resistance training') AND ('quality of life'/exp OR 'quality of life') AND ('diabetes mellitus'/exp OR 'diabetes mellitus') AND ('adult'/exp OR adult)

The databases included but were not limited to PubMed, SCOPUS, Physiotherapy Evidence Database (PEDro), Cochrane Library, MEDLINE via PubMed, Embase, and Science Direct. The reference lists of all studies selected for critical appraisal were screened for additional studies. Articles published between 2012 and 2024 in English were searched. Abstracts were reviewed first, and the full text of the articles identified by the search was reviewed based on their title, abstract, and description of the subjects.

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG	HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Office of the Deputy Vice-Chancellor (Research & Innovation)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
ETHICS WAIVER

05/05/2025

Ref: W25/05/02

TO WHOM IT MAY CONCERN

Waiver: This certifies that the following research does not require clearance from the Human Research Ethics Committee (Medical)

Investigator: Ms U Ramlakan Naraidas
Student No. (if appropriate): 00 0641 5d
Staff No. (if appropriate):

Supervisor: Dr N Benjamin-Damons, et al

School: Therapeutic Sciences
Department: Physiotherapy
Division: Faculty of Health Sciences

Project title: *The effectiveness of strength training programmes on quality of life in adults with Type 2 Diabetes: a systematic review*

Degree: MSc

Reason: Review of information in the public domain
No human participants will be involved in the study

Professor P Ruff
Chairperson: Human Research Ethics Committee (Medical)

Research Office Secretariat:
Third Floor, Phillip Tobias Building, corner of St Andrews and York Roads, Parktown, Johannesburg 2193
Postal address: Private Bag 3, Wits 2050
Tel Nos: +27 (0)11 717 1234/1252/2658/2700
Office E-mail: HREC-Medical.ResearchOffice@wits.ac.za
Website:
https://www.wits.ac.za/research/researcher-support/research-ethics/ethics-committees/