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The barriers and facilitators of physical activity participation among people living with type 2 diabetes: Systematic Review

This Dissertation is submitted in full fulfilment of the requirements for the degree of MSc of Bangor University

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DECLARATION

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Signed..... (Candidate)

Date.....30.09.2020.....

STATEMENT 1

This dissertation is the result of my own investigations, except where otherwise stated. Where correction services have been used, the extent and nature of the correction is clearly marked in a footnote.

Other sources are acknowledged by appropriate referencing.

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STATEMENT 2

I hereby give consent for my dissertation, if accepted, to be available for interlibrary loan, and for the title and summary to be made available to outside organisations.

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Abstract

Background: Type 2 diabetes mellitus (T2DM) and its complications are among the leading reasons of serious mortality and health burden globally. Exercise is one of the commonly suggested preventions/ interventions for T2DM. Although exercise has a significant improving effect on T2DM and complications, people with T2DM tend to live a sedentary life. **Objectives** in this systematic review: (i) is to identify and synthesise available qualitative and quantitative studies exploring the barriers and facilitators of PA among people living with T2DM; (ii) is to investigate that is there an association between perceived PA benefits and PA level in people with T2DM, (iii) is to explore that is there an association between perceived PA barriers and PA level in people with T2DM, and (iv) is to investigate that is there an association between perceived PA facilitators and PA level in people with T2DM.

Methods: This systematic review was undertaken using the advice of the Preferred Reporting Items and Meta-analysis (PRISMA). To gather all relevant studies included both qualitative and quantitative studies related to the topic. Therefore, this review was designed as a mixed-methods systematic review. The review was limited in English published between 2009 and 2020. The participants that were included in the study were over 18 years of age and were diagnosed with T2DM. A systematic search of four databases (CINAHL, MEDLINE, PubMed, and Web of Science) was conducted. The quality assessment was conducted with Mixed Methods Appraisal Tool (MMAT) (2011 version). Data extraction was made with separate Joanna Bridge Institution (JBI) templates for qualitative and quantitative studies. Data synthesis was made with thematic synthesis for qualitative studies and narrative synthesis for quantitative studies followed by a third synthesis to combine the previous synthesis.

Results:

Overall, 1,078 articles were identified that are 237 articles via MEDLINE, 259 articles via PUBMED, 165 articles via CIHANL, 417 articles via Web of Science. A total of 30 studies, consisting of 18 quantitative, 11 qualitative, and one mix-method study were included in the review. The sample size in the included studies ranged from 10 to 2,866 participants. The total population with T2DM was 7,884 in thirty studies. Perceived facilitators and perceived barriers

to physical activity were defined with 15 domains and 24 themes as a result of narrative and thematic synthesis.

Discussion:

The present systematic review provided evidence for better understanding the facilitators of and barriers to physical activity that people with T2DM and it identified in the literature by researching what is known about people with T2DM in terms of the barriers or facilitators of physical activity.

Conclusion:

There are many barriers and facilitators to being physically active defined by people with T2DM. Health professionals, municipalities, and the media have a significant role to decrease perceived barriers to exercise among people with T2DM. The future studies could focus on the effectiveness of health professionals, municipalities, and the media in the increase of physical activity among people with T2DM.

CONTENT

LIST OF TABLES

List of Abbreviation

ADA	American Diabetes Association
CINAHL	Cumulative Index to Nursing and Allied Health Literature
DM	Diabetes Mellitus
DALYs	Disability-Adjusted Life Years
EBP	Evidence Based Practice
ESRD	End-Stage Renal Disease
FPG	Fasting Plasma Glucose
GDM	Gestational Diabetes Mellitus
HbA1c	Glycated Haemoglobin A1c
IGT	Impaired Glucose Test
IFG	Impaired Fasting Glucose
IDF	International Diabetes Federation
LEA	Lower-Extremity Amputations
MEDLINE	Medical literature online
MMAT	Mixed Method Appraisal Tool
NHS	National Health Service
PA	Physical Activity
PECO	Population, Exposure/Intervention, Comparator, Outcome
PICO	Population, Intervention, Comparator, Outcome
PRISMA	Preferred Reporting Items for Systematic Review and Meta-analysis
RPG	Random Plasma Glucose
SCI	Science Citation Index
SPIDER	Example, Case of Interest, Design, Evaluation, Research Type
SR	Systematic Review
SRs	Systematic Reviews
T1DM	Type 1 Diabetes Mellitus
T2DM	Type 2 Diabetes Mellitus
UKPDS	United Kingdom Prospective Diabetes Study

1-Introduction

1.1 Definition of diabetes mellitus

Diabetes mellitus (DM) is a serious and long-term condition that happens when any or enough insulin cannot be produced by body or body cannot efficiently use the insulin when there is increased level of glucose in a person's blood (International Diabetes Federation (IDF), 2019). Insulin, which is produced in the β-cell of pancreas, is a vital hormone because it allows to glucose from bloodstream to enter the body's cells in order to obtain energy from glucose (Chakkera, Kudva, and Kaplan, 2017; Prifer, Halter, and Porte, 1981). In the result of the inability or the lack of insulin happens high levels of blood glucose called hyperglycaemia, which is the clinical sign of DM (Rodriguez-Gutierrez and McCoy, 2019).

The diagnosis of diabetes is considered as the levels of impaired glucose test (IGT), impaired fasting glucose (IFG), fasting plasma glucose (FPG), two-hour plasma glucose (2-h PG), HbA1c, and random plasma glucose (RPG) (American Diabetes Association (ADA), 2017). The values to diagnose diabetes should be HbA1c≥ 48 mmol/mol (equivalent to 6.5%) or FPG≥ mol/L (126mg/dl) or MF= 6.1- 6.9 mmol/L (110-125 mg/dl) or 2-h PG ≥11.1 mmol/L (200 mg/dl) or RPG > 11.1 mmol/L (200 mg/dl) and if measured 2-h PG ≥7.8 and < 11.1 mmol/L (140-200mg/dl) and if measured 2-h PG <7.8 mmol/L (140 mg/dl) or IGT < 7.0 mmol/L (126 mg/dl) (ADA, 2017; IDF, 2019). When someone is diagnosed with DM, the type of diabetes should be decided for appropriate treatment. Type 1, type 2, and gestational diabetes are called as the main categories of DM, and there are other kinds of DM e.g. maturity onset diabetes of the young, monogenic diabetes and neonatal diabetes mellitus, and (IDF, 2019).

Type 1 diabetes mellitus (T1DM), which causes lifespan dependency on daily insulin injection, is posed by the autoimmune destruction of pancreatic beta cells responsible for insulin production (Atkinson, 2012). The symptoms of type 1 in children are especially characterised with polyuria, polydipsia, weight-loss, and nearly one-third apply with diabetic ketoacidosis (ADA, 2017; Janez et al., 2020; WHO, 2006). T1DM is typically thought that it develops during childhood or adolescence, however, it might develop over the all lifetime, even over the age of 80 years (Lernmark, 1999; Janez et al., 2020). The ethology of T1DM has not still been understood, however, it is thought that environmental factors have an important role in the development of

T1DM as much as genetic factors (Forouhi and Wareham, 2019; Lenmark, 1999). According to the estimate of IDF (2017), >96,000 new cases of type 1 diabetes are observed globally every year among children and adolescents aged<15 years (IDF, 2017). The countries with the top ten highest T1DM burden by number are the UK, USA, China, Brazil, German, Algeria, Nigeria, Saudi Arabia, India, and the Russian Federation, comprising approximately 60% of all new T1DM cases (Forouhi and Wareham, 2019). The incidence of T1DM in children also changes almost 400-fold among countries (Forouhi and Wareham, 2019).

Gestational Diabetes Mellitus (GDM) is defined when a glucose intolerance develops in a woman beginning and first diagnosis between 24 to 28 weeks of pregnancy (ADA, 2017; IDF, 2019; WHO, 2006). Mothers diagnosed with diabetes in the first trimester are mostly classified as having pre-existing type 2 diabetes mellitus (T2DM) or very rarely T1DM (ADA, 2017). The prevalence of GDM is 9.2% in the USA, 16.3% in Qatar, 10.8% in Switzerland (Gilbert et al., 2019). GDM is also the one cause of decreased psychosocial well-being: women with GDM have the risk of developed postpartum or antenatal depression two to four times more (Hinkle et al., 2016). Postpartum depression is associated with a reduction in physical activity and a rise in eating, hence, these women will be confronted at higher risk of weight and future diabetes (Nicklas et al., 2013; Staiano, Marker, Martin, and Katzmarzyk, 2016).

In the people with type 2 diabetes mellitus (T2DM) do not function properly the feedback loops between insulin secretion and insulin action (Stumvoll, Goldstein, and Haeften, 2005). In the result of this dysfunction, the action of insulin in insulin secretion by pancreatic islet β-cells (β-cell dysfunction in T2DM) and insulin sensitive tissues e.g. muscle, adipose, and liver tissue (insulin resistance in T2DM) are developed, which causes abnormal blood levels of glucose (Stumvoll, Goldstein, and Haeften, 2005). T2DM accounting for nearly 90% of all diabetes cases is the most common type of diabetes in the world (ADA, 2015; IDF, 2017). T2DM mainly affects adults (Forouhi and Wareham, 2019). The ethology of T2DM is complex and associated with unalterable risk factors such as genetic, age, ethnicity, race and alterable factors such as physical activity, diet, and smoking (Sami, Ansari, Butt, and Hamid, 2017). There is a lot of evidence that many cases of T2DM can be prevented with lifestyle modification, although individual predisposition to T2DM depends on a strong genetic basis (Zheng, Ley, and Hu, 2018).

As a result, there are 3 main types of diabetes (T1DM, T2DM, GDM). This review will look at people with T2DM (or following reasons (see section 1.2, and 1.3) due to accounting for 90% of all kinds of diabetes.

1.2. Prevalence of DM

Diabetes mellitus is one of the most common chronic illnesses in the world, and continues to rise in numbers and importance, as changing lifestyles caused increased obesity, and decreased physical activity (Shaw, Sicree, and Zimmet, 2009). The number of people with DM and in the age bracket 20-79 was nearly 151 million or approximately 4.6% in all IDF member nations in the year 2000 (IDF, 2000). Amos, Carty and Zimmet (1997) projected that the global burden of diabetes to be 124 million people in 1997 and estimated that this figure would rise to 221 million people by the year 2010. In the IDF (2009), it was reported that roughly 285 million people globally or 6.6% of the adult population, will be diagnosed with diabetes in 2010. According to King, Aubert, and Herman (1998), it is estimated that the global burden of diabetes was at 135 million in 1995, and this figure will reach 299 million by the year 2015. However, in 2011, approximately 366 million people globally or 8.3% in the age bracket 20-79 had T2DM (Sami, Ansari, Butt, and Hamid, 2017). Furthermore, the IDF (2009) estimated that 438 million people, or 7.8% in the age group 20-79 are possibly to have diabetes by 2030. However, in the WHO (2016) was reported that 422 million people (1 in 11 adults) over 18 years old were already diagnosed with diabetes in 2014. According to the IDF (2015), the number of people with diabetes will globally reach nearly 642 million (1 in 10 adults) by 2040.

Diabetes mellitus has skyrocketed in the last two-decade years, and it is expected that it will continue to climb in the future years. These figures are most concerning because a rise in diabetes prevalence will raise the number of acute and chronic illnesses in the overall population, with too deep effects on quality of life, economic burden, and demand on health services (Harding et al., 2019).

1.3. The burden and complication of T2DM

Projected global healthcare costs to treat and prevent diabetes and its complications are expected to total at least $376 billion in 2010 (IDF, 2009). This cost was projected to exceed a total at least $490 billion by 2030 (IDF, 2009). However, the health costs related to diabetes

were estimated to range from $673 billion to $1,197 billion in 2015 (IDF, 2017). There was also an important increase from $232 billion to $ 727 billion in health expenditure related to diabetes from 2007 to 2017 (IDF, 2019). The global total diabetes related health expenditure will be $760 billion in 2019, and spending will increase $825 billion by 2030 and $845 billion by 2045 (IDF, 2019). The average annual health expenses for diabetic people with four or more complications is 20 times more than people with diabetes without complications (Marcellusi et al., 2016). The treatment of T2DM and its related complications encompassed roughly 12% of the global health spending in 2015 (IDF, 2015).

Diabetes and its complications, which are considered with macrovascular complications and microvascular complications, are major cause of mortality and morbidity (Cunningham et al., 2018; Zheng, Ley, and Hu, 2018). Microvascular complications, such as end-stage renal disease (ESRD), along with lower-extremity amputations (LEA), retinopathy and neuropathy, and macrovascular complications of diabetes, including stroke, coronary heart disease, and peripheral vascular disease, are responsible for much of the burden associated with diabetes (Sjöström, Peltonen, and Jacobson, 2014; Wadhwani, Chittawar, Gedam, and Khandare, 2020). Furthermore, psychological problems are significant problems in T2DM. As such, the prevalence of depression is higher in people with T2DM than those without diabetes (18% and 10% respectively) (Nouwen et al., 2011). Diabetes and its complications cause an incredible increase in disability-adjusted life years (DALYs) and mortality in the world (Zheng, Ley, and Hu, 2018). According to GBD 2015 Risk Factors Collaborators, 2016, while a high fasting level of glucose was the tenth most common global risk factor for DALYs in 1990, it was ranked in the fourth most common in 2005 and the third most common in 2015. There have been nearly 5.0 million deaths in the world from diabetes, which is equivalent to one death every six seconds (IDF, 2015). However, the available evidence exhibits that self-management implementations could significantly reduce all-cause diabetes related complications and mortality risk (Byers, Garth, Manley, and Chlebowy, 2016; He et al., 2017; Litwack et al., 2013).

1.4. The significance of self-management in T2DM

The self-management of T2DM involves a considerable attention to physical activity, glucose monitoring, management of diet, consistent use diabetes medication and/or insulin, and ongoing to medical care (Cunningham et al., 2018; Gregg et al., 2007; Zheng, Ley, and Hu, 2018).

A key aim of diabetes self-management is the control of HbA1c, which is a quantity of average blood glucose over several months (Cunningham et al., 2018). The target level for HbA1c is <7.0 (ADA, 2017; IDF, 2019; IDF, 2017). The implementations of good self-management of diabetes decrease significantly the level of HbA1c (Litwack et al., 2013). The measurement of lower HbA1c delays the starting of nephropathy, neuropathy, peripheral vascular disease, coronary heart disease, and retinopathy which are the commonest complications of diabetes (Thomas, Alder, and Leese, 2004). The level of lower HbA1c means that probability of developing diabetes-related complications will decrease myocardial infarction by up to 14%, and reduce microvascular diseases by up to 37% (U.K. Prospective Diabetes Study Group [UKPDS], 1998).

All diabetes self-management implementations (e.g., diet, monitoring blood glucose, taking medicine, and physical activity) have a considerable role in the control of HbA1c, and all implementations are fundamental components for the management of diabetes. Thus, people with DM should consider all implementations in their daily life. However, reviews generally focus on only one or two of self-management implementations in order to enhance specific knowledge about the barriers/facilities or the effectiveness of self-management implementation for people with T2DM. Therefore, this review focused on physical activity for people with T2DM.

1.5 Physical Activity

Physical activity (PA) is defined as body muscular movements generated by contraction of the musculoskeletal system that raises energy consuming (Piercy et al, 2018). Many activities can be defined as PA such as walking, housekeeping, using stairs, running, swimming, muscle strength and aerobic activity (Kadariye and Aro, 2018). If PA is repetitive body movements in structured and planned methods, it is defined as exercise (Piercy et al., 2018).

PA might be categorised as muscle-strength and aerobic activity. Cardio-activity or aerobic-activity contains use of the body's large muscles for a continued period of time (at least 10 nonstop minutes) (Sigal et al., 2004). Its three components are frequency, intensity and duration. The intensity is defined as low, moderate and vigorous along with the energy consuming (Sigal et al., 2004). Metabolic Equivalent of Task (MET) is stated as the energy

expenditure of PA. A low intensity PA is 1.1-2.9 METs, moderate intensity consists of 3.0-5.9 METs and vigorous intensity consists of 6.0 or more METs (Sophia et al., 2018).

1.6 The significance of physical activity in T2DM

According to ADA and WHO, people with T2DM should practice at least 150 minutes per week of moderate-intensity aerobic physical activity (50%–70% of maximum heart rate), circulate over at least days/week with no more than 2 sequential days without exercise along with weight training exercises (ADA, 2013; WHO, 2004). PA has been recommended as an integral component of self- management in people with T2DM which helps decrease premature mortality and macrovascular complications (Advika, Idiculla, and Kumari, 2017; Sluik et al., 2012). PA improves systemic inflammation, arterial stiffness, body mass index, and glycaemic control (Fagour et al., 2012; Kaizu et al., 2014; Kramer, 2011; Umpierre, Paila, Ribeiro, and WHO, 2016). PA not only delays or prevents the occurrence of long-term diabetes complications such as nephropathy, retinopathy, and neuropathy, but also could decelerate the progression of existing complications (Pati et al., 2019). Moreover, PA has positive effects on metabolic abnormalities, insulin action, and glycaemic control associated with T2DM (Pati et al., 2019, as cited in, Hayes & Kriska, 2008, p.1). Consequently, PA plays a key role in the management of T2DM (Pati et al., 2019; Zheng, Ley, and Hu, 2018).

1.7 Literature review/ and Research question, Aims, Objectives

There are many evidences in literature supporting the positive effects of PA on the glycaemic control for people with T2DM. In the previous systematic reviews, it were found that structured exercises such as resistance training and/or aerobic exercise, are associated with the decrease of HbA1c in people with T2DM (Cai et al., 2017; Liubaoerjijin, Terada, Fletcher, and Boule, 2016; Umpierre, Paila, Ribeiro, & Kramer, 2011). Umpierre, Paila, Ribeiro, and Kramer (2011) also evaluated that taking part in structured exercises more than 150 minutes per week improves HbA1c more effectively.

Blankenship et al. (2019) recruited 30 sedentary people with T2DM (39-74 years old). They assessed the effect of 20, 40, or 60 minutes of activity on a daily basis and postprandial-glycemia by either taking breaks by sitting down after each meal (BR), or walking after breakfast in the free-living environment. They randomly divide thirty people into three groups (BR, WALK,

and Control). They assessed that people in the WALK group tended to shorten the daily duration of hyperglycemia compared with Control (P≤ 0.0875). There were not any differences in the duration of hyperglycemia of people in the BR and Control groups. Blankenship et al. (2019) found that continuous walking is more effective than breaks from sitting in lowering daily hyperglycaemia in the free-living environment. Cassidy et al. (2016) recruited randomly 28 patients with T2DM. They applied high intensity intermittent training (HIIT) for diabetic patients in the intervention group. There was a 39% significant decrease in liver fat and a decrease HbA1c ($p<0.5$ for both). As a result, they found that HIIT improves significantly cardiac structure and function along with the highest reduction in liver fat. Way, Hackett, Baker and Johnson (2016) found that regular exercise improves remarkably insulin sensitivity, which can continue for 72 hours or longer after the last exercise training. According to Way, Hackett, Baker and Johnson (2016), their findings support that short periods of inactivity (e.g., 72 hours) might not result in a loss of insulin sensitivity.

Although the majority of evidence supports the importance of PA for people with T2DM, many studies have recognised that people with DM participate in less PA than non-diabetics, have poor metabolic control, and tend to live more sedentary lifestyles (Gizaw et al., 2017;Hill et al., 2020; Joseph et al., 2015; Palermo and Sandoval, 2016; Vibha et al., 2018). To illustrate, Sophia et al. (2018) found that the total PA intensity score of diabetic participants in their study was 2,744 MET- minutes per week. The mean intensity score for walking was 1,454 MET- minutes per week, and the mean duration was 79 minutes per day. The mean intensity scores for vigorous and moderate PA were 399 and 577 MET minutes per week, respectively, and the mean duration were 17 and 31 minutes per week respectively. These scores were less often and at lower intensity than is proposed by the ADA and WHO (ADA, 2013; WHO, 2004).

Korkiangas, Alahuhta and Laitinen (2009) examined perceived barriers to exercise among people at high risk or already T2DM in their systematic review. They found that there were two kinds of barriers to regular exercise: external and internal barriers. The external barriers were related to lack of social support or individual’s own decision-making (weather). The internal barriers were related to emotional (shame), an individual's own decision-making (lack of time), and overweight. According to Korkiangas, Alahuhta and Laitinen (2009), these barriers can be resolved with counselling. As a result, previous review has focussed on internal and external

barriers. However, they did not consider facilitator factors engaging to PA. This review was expanded by investigating both barriers and facilitators to PA among people living with T2DM.

In conclusion, a preliminary search of the Cochrane Database of Systematic reviews and PROSPERO was conducted, and there is no current systematic review investigating the barriers and facilitators of physical activity in people living with T2DM. Therefore, this systematic review **aims**; (i) to review evidence to better understand the facilitators and barriers to physical activity that people with T2DM can come across. (ii) Identify gaps in the literature by researching what is known about people with T2DM in terms of physical activity. In this regard, this study will explore the following research question;

Research Question

What are the barriers and facilitators of physical activity participation among people living with type 2 diabetes?

Objectives

The objectives of this systematic review; (i) is to identify and synthesise available qualitative and quantitative studies exploring the barriers and facilitators of PA among people living with T2DM; (ii) is to investigate that is there an association between perceived PA benefits and PA level in people with T2DM, (iii) is to explore that is there an association between perceived PA barriers and PA level in people with T2DM, and (iv) is to investigate that is there an association between perceived PA facilitators and PA level in people with T2DM.

This information will guide future research and support the development of the intervention to overcome barriers by providing better understanding of the barriers faced by people with T2DM. This information will also guide future research and support the development of the intervention to expand and increase facilitator factors determined by people with T2DM.

2. METHODS

2.1 Methodologies for systematic review

The decisions that are required to provide the efficient and effective health care services should be depended on the best available evidence. Systematic reviews (SRs) providing high quality knowledge syntheses are the best source to provide such information (Hartling et al., 2016). Systematic Review (SR) is the implementation of strategies that limit bias in the critical appraisal, synthesis, and assembly of all relevant studies as possible to contribute to accomplishing reliable estimates of effects on a specific topic (Chalmers, Hedges, & Cooper, 2002; Lefebvre et al., 2011; Rudnicka and Owen 2012; Siddaway, Wood and Hedges, 2019). In the achieving of the process of SRs, scientific daintiness is that SRs are regarded a study on ability of summarizing evidence on a certain clinical issue, its own worth, at the base of interests of evidence-based practice (EBP) accepted and attempts as a reliable resource of information on the efficiency of health care (Portney, 2020).

EBP in the research process includes an important part of disseminated research (Portney, 2020; NHS, 2013). Evidence-based information is the highest reliable way in making the best possible decision with all health care professionals for a certain consumer because it provides the latest research evidence and the best available scientific information (Brownson, Fielding, and Maylahn, 2009; Parks et al., 2017; Schlosser, 2006). However, a widespread misconception is that EBP is driven by research evidence only (Schlosser, 2006). SRs rank at the top of hierarchies of evidence as they provide significant opportunity for public policy and informing practice (Siddaway, Wood & Hedges, 2019).

This study was designed as a mixed-method systematic review, which provides a combination synthesis and analysis of data from both qualitative and quantitative research to present a better understanding of individuals' perceptions, values, experiences within a single systematic review (Heyvaert, Maes, and Onghena, 2013; Harden and Thomas, 2005). Mix-method reviews have an important advantage over the synthesis of only qualitative or quantitative studies in that they could lead to a very diverse understanding of a topic (van Grootel, Nair, Klugkist, and Wesel, 2020).

This study is conducted and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) of qualitative and quantitative studies (Moher, Liberati, Tetzlaff, and Altman, 2009).

2.2 Research question

The key point of SRs is a review of an apparently formulated question that uses clear and systematic methods to critically appraise, choose, and detect relevant research, and to gather and analyse data from the studies that are included in the review (Van Tulder, Furlan, Bombardier, and Bouter, 2003). According to Heddle (2007), the question should be properly organised to acquire the best and the latest available evidence for the questions rising in healthcare professionals, doctors, nurses, and to progress the quality of healthcare services. The base of the process of formulated questions should be about what topic, for whom is the result of the research organized, and what does the researcher want to know, and why the result of the study is significant (Siddaway, Wood and Hedges, 2019). The search tools to provide the most comprehensive and unbiased research potential have been developed, such as PICO (Population, Intervention, Comparator, Result), PICOS (Population, Intervention, Comparator, Result, Study Design) and SPIDER (Example, Case of Interest, Design, Evaluation, Research Type). Methley et al. (2014) defined that the PICO is a fully comprehensive tool but the PICOS tool should be used where resources and time are restricted, and the SPIDER tool would not be suggested due to the risk of not identifying relevant articles.

The research question for this study is ‘’What are the barriers to and facilitators of physical activity participation among people living with type 2 diabetes?’’ This question is not exactly suitable in terms of PICO, PICOS, and SPIDER frameworks as this study includes all relevant qualitative and qualitative studies. Therefore, Population, Exposure, Comparator, Outcome (PECO) was used to identify suitable studies. The PECO facilitates the interpretation of the trueness of the findings depending on how well the main research findings demonstrate the original question (Morgan et al., 2018). According to the PECO, the question components comprise adults with T2DM for Population, physical activity for Exposure, not for Comparator, and perceived barriers and facilities for Outcome. TABLE 1 demonstrates PECO format for the study.

TABLE 1: PECO format

Population	Exposure	Comparator	Outcome
Adults with type 2 diabetes	Physical activity	No	Perceived barriers and facilities

2.3 Eligibility criteria

The specification and reporting of eligibility criteria is a remarkable part in the systematic review process (Bettany & Saltikov, 2012; McCrae & Pursell, 2015). Eligible criteria should be explicitly reported to the reader in order to understand the implications and rationale for the review results (McCrae & Pursell, 2015). According to McCrae, Blackstock and Pursell (2015), eligibility criteria should be detected with scope of literature reviewed, reporting of papers rejected or added, and usefulness of exclusion criteria. McCrae, Blackstock and Pursell (2015) also highlighted that eligibility criteria should be detected before the search strategy. Detecting firstly search strategy is a major risk of bias because it causes retrospective boundary of the scope of the review, the possible exclusion on the basis of study findings rather than legitimate criteria (McCrae, Blackstock, and Pursell, 2015).

A scoping review was firstly made to detect eligible criteria in Google Scholar and Cochrane Library in this study. Therefore, the following eligible criteria are identified in this systematic review.

The inclusion criteria was applied: (i) studies examining people living with T2DM, (ii) studies evaluating the barriers, facilitators, or both to physical activity, (iii) studies published after 2009. A systematic review related to the perceived barriers (outcome) to physical activity (exposure) for T2DM (population) published in 2009 was found in the result of all screening. Thus, the studies published after 2009 were thought as eligible studies.

The following exclusion criteria was applied: (i) studies reporting on mixed samples where data on people with T2DM were not assessed separately from those with other conditions such as gestational diabetes and type 1 diabetes, (ii) studies involving perception from only health care

professionals, (iii) studies promoting exercise or physical activity without consideration of barriers or facilities, (iv) studies including literature review, systematic review, review, articles and abstract that do not supply enough information to assess the study, (v) studies not publishing in English, (vi) studies published before 2009.

The eligibility criteria were set up with the PECO strategy and the type of study in **TABLE 2.**

TABLE 2: Eligible Criteria

	Inclusion	Exclusion	Rationale
Design of Studies	Any type of studies (Qualitative studies, Quantitative studies, Mix method studies)	Reviews Protocols Reports	Qualitative or quantitative studies were included to obtain a comprehensive information about barriers and facilities of exercise. Thus, this systematic review was designed as mix-method systematic review.
Population	People with type 2 diabetes mellitus	1-People with type 1 diabetes mellitus, 2-Women with gestational diabetes mellitus, 3- People at risk for diabetes mellitus, 4-People with heart disease, hypertension, stroke and diabetes mellitus,	1-Type 2 diabetes mellitus is the most common diseases in the world. Patients with type 2 diabetes do not sufficiently consider physical exercise. 2- People with T2DM should be specifically searched to attain the right knowledge about their physical activity perceptions
Exposure	Physical activity	1- Studies focusing on the effect of exercise on diabetes rather than perceived exercise barrier and facilities for type diabetes patients. 2-Studies focusing only on the effect of any technological	To answer the question designed by this mix-method systematic review.

		tool for exercise among type 2 diabetes.	
Outcomes	Perceived barriers and facilities of exercise among patients with type 2 diabetes mellitus	The studies that do not evaluate barriers or facilities of exercise	To answer the question designed by this mix-method systematic review
Language	English language studies	Non-English language studies	Restricted studies for translation
Time	Studies published between 2010 and 2020	Before 2010 studies	There was a systematic review published in 2009 years on the same topic.

2.3.1 Types of the study to be included

Eligible studies include qualitative, quantitative, and mixed method studies focused on the barriers, facilitators, or both to exercise among type 2 diabetes adults. An appropriate methodological framework should be chosen ensuring that the results of a study are robust (Rust et al., 2017). Qualitative methods might be used when intensely exploring a topic while seeking to preserve the context (Maxwell 2012; Newing, 2010). Quantitative method is more generally used in order to test hypothesis-driven questions when pre-existing data are accessible (Newing, 2010). Quantitative studies predictably use large sample size and statistical analyses to demonstrate generalizable conclusions.

Findings from qualitative studies are counted to be '' pronouncements, judgements, the data and integrated discoveries searchers have presented about the experiences or events under investigation (van Grootel, Nair, Klugkist, & Wesel, 2020). A qualitative study prefers to search specific cases for maximum investigation using an inductive approach with generally smaller, non-random, and subset of a population (Rust et al., 2017). Mix-method studies comprise both quantitative and qualitative methods (Tezkereci and Kulakac, 2018; van Grootel, Nair, Klugkist, & Wesel, 2020). The robustness of qualitative and quantitative methods is depending on different nuances. While quantitative studies attempt for internal and external validity, qualitative studies attempt for often transferability, and credibility (Maxwell, 2012; Glaser,

Strauss, and Strutzel, 1968; van Grootel, Nair, Klugkist, and Wesel, 2020). Therefore, quantitative, qualitative, and mix-method studies are included in this review to achieve a comprehensive knowledge about barriers and facilitators of physical activity for people with T2DM.

2.3.2 Population

The participants that were included in the study were over 18 years of age and were diagnosed with T2DM. The cause, treatment options, severity, and duration of the disease were not considered as a limitation to assess barriers and facilitators of PA among people with T2DM. The studies involving diseases such as stroke, cancer, heart diseases, orthopaedic diseases or hypertension were excluded. People who had T2DM along with other chronic diseases were included in the study, however, the data provided about them was separately presented from the other conditions (e.g. cancer).

2.3.3 Exposure/ Intervention

A study design describing reasons for barriers or facilitators of physical activity among adult people with T2DM was included. Physical activity was defined as exposure in this study. The term 'physical activity' means walking, running, swimming, physical strength training, aerobic exercise, or walking with a dog.

2.3.4 Comparator

Participants in the study were not evaluated with any comparison group.

2.3.5 Outcome

The outcomes of this review included; (i) Barriers to physical activity participation among adult people with T2DM, (ii) Facilitators of physical activity participation among adult people with T2DM.

2.4 Search Strategy

The development and preparation of this systematic review used the rules of the PRISMA (Moher, Liberati, Tetzlaff, and Altman, 2009). PRISMA focuses on randomised trials; however, PRISMA could also be used as a base for reporting systematic reviews of other kinds of research, especially assessments of interventions (Moher, Liberati, Tetzlaff, & Altman, 2009). A comprehensive search of four databases was conducted in the library databases via Library of Bangor University through the following four databases; MEDLINE via Ovid (MEDLINE from 1946 to April, 2020), Web of Science (All databases from 1950 to April, 2020), PubMed (from 1966 to April, 2020), and CIHANL (from 1806 to April, 2020). These databases presented an extensive search opportunity for topics relating to health-science, hence, they were used in this study. The reference lists of including studies were also scanned to assemble all available data for this study. The protocol of this systematic review was registered in PROSPERO with CRD42020188011 number.

A facet analysis was carried out by dividing the question into three parts- population (people with T2DM), exposure (physical activity), and outcomes (perceived barriers and facilitators to physical activity). A systematic database search was carried out using a combination of Medical Subject Heading (MeSH) to attain a sensitive search. MeSH terms were arranged in a hierarchy, from broader terms to more specific terms, and these terms were updated weekly and reviewed annually (Ecker & Skelly, 2010). Truncation (*) was used to ensure all possible word endings. The results were combined by using the Boolean operator 'OR' in each column. After that, the results of the four columns by using the Boolean operator 'AND' were combined to attain a comprehensive search to retrieve all relevant topics. MeSH terms and synonym terms were determined by the terms of MEDLINE via Ovid. The following search terms and operators were conducted to find recent empirical studies:

((diabetes Mellitus OR type 2 diabet* OR adult-onset diabet* OR maturity-onset diabet* OR diabetes mellitu*, adult onset OR diabetes mellitus, non insulin dependent diabetes OR non-insulin dependent diabet* OR noninsulin dependent diabet* OR nidd* OR type ii diabetes OR T2D OR T2DM) AND (exercise* OR activity*, physical OR aerobic exercise* OR exercise*, aerobic

OR physical exercise* OR physical activity*) AND (facility* OR motivation* OR benefit*) AND (barrier* OR challenge*)

A free text in **TABLE 3** is formed to organise these terms.

TABLE 3: Free-text

Index-MeSH terms	Diabetes mellitus, type 2		Exercise		Facilities		Barriers
Free-text	diabetes Mellitus, type 2 diabetes mellitus **OR** type 2 diabete* **OR** type 2 diabetes mellitu* **OR** adult-onset diabetes mellitu* **OR** maturity-onset diabetes mellitu* **OR** diabetes mellitu*, adult onset **OR** diabetes mellitus, non insulin dependent diabetes **OR** non-insulin dependent diabet* **OR** noninsulin dependent diabet* **OR** nidd* **OR** type ii diabetes **OR** T2D **OR** T2DM	**AND**	exercise* **OR** activity*, physical **OR** aerobic exercise* **OR** exercise*, aerobic **OR** physical exercise* **OR** exercise*, physical **OR** physical activity*	**AND**	facility* **OR** motivation* **OR** benefit*	**AND**	barrier* **OR** challenge*

***Truncation**

2.5 Quality assessment

EBP reviews depend on an evaluation of high risk of bias to deliver a threshold between included and excluded studies (Boland, Cherry, and Dickson, 2017; Viswanathan et al., 2018). In the process of review, the synthesis of qualitative and quantitative studies, and the interpretation of heterogeneous findings rely on criteria the assessment of risk of bias as low, medium, high, or unclear (Boland, Cherry, and Dickson, 2017; Viswanathan et al., 2018). A systematic deviation or error from the truth, in inferences or results is determined as risk of bias affecting internal validity or the circumstances being studied (Higgins and Green 2011; Viswanathan et al., 2018). Studies affected by bias could result in false positive or false negative due to relations by underestimate-or-over the true effect (Ballard and Montgomery, 2017). Risk of bias assessment is mostly conducted to identify internal or external validity, performance, attrition, reporting, selection, or detection bias because these type biases are seen more common in studies (Pollock and Berge, 2018).

Mixed method researches are analysed with general criteria to plan, design and report, however, assessment of the methodological quality of mixed methods studies could not be applied with any key specific criteria (Creswell, and Clark, 2017; O'Cathain, Murphy and Nicholl, 2008). Therefore, many risks of bias assessment tools might be used in quality assessment such as the Mixed Methods Appraisal Tool (MMAT), the Cochrane Risk of Bias, CASP, the Joanna Briggs Institute (JBI) AMSTAR, ROBIS tools.

The risk of bias assessment in this study was conducted with MMAT (2011 version) in **APPENDIX 1** because this tool presented an opportunity for the researcher in order to assess qualitative, quantitative and mixed methods studies (Souto et al., 2015). The MMAT has been piloted across all methodologies and has established content validity (O'Cathain, 2010). For each study type, the overall quality score was calculated. For example, the quality score was 1/4, meaning that one criterion is met (25%) (Pluye et al., 2011).

The MMAT consists of five specific sets of criteria: (1) a 'qualitative' set for qualitative studies , and qualitative components of mixed methods research; (2) a 'randomized controlled' set for randomized controlled quantitative studies, and randomized controlled components of mixed methods research; (3) a 'non-randomized' set for non-randomized quantitative studies, and

non-randomized components of mixed methods research, (4) an 'observational descriptive' set for observational descriptive quantitative studies, and observational descriptive components of mixed methods research; and (5) a set 'mixed methods' for mixed methods research studies (Pace et al., 2012 , pp. 2).

The critical appraisal of all included studies was conducted by two independent reviews (OO, AC). The scores of studies were recorded by both reviews to facilitate comparison of appraisal scores. Disagreements on the quality of study were solved by debating with a third reviewer (RJ). The studies did not completely exclude the basis of quality. As such, quality was considered when interpreting results.

2.6 Data extraction

The data analysed in the systematic review was obtained from the results extracted from a personal research paper relevant to the systematic review question (Munn,Tufanaru, and Aromataris, 2014). Two standardised, pre-piloted templates were used to undertake data extraction and assessment of study quality. One of the Joanna Bridge Institution (JBI) templates was used when including qualitative studies in this systematic review. A second template was used for quantitative studies (e.g. cross-sectional, case-control). **APPENDIX 2** demonstrates the kinds of JBI templates that were used in this study.

All studies were screened to review titles and abstracts in order to determine the appropriate studies by the reviewer (OO). Relevant studies during the screening process were conducted by searching the full text of the studies. Data extraction was conducted by two independent reviewers to increase transparency. The discrepancies through the process of data extraction were solved by consensus and discussion with a third reviewer. The following characteristics were extracted: author, year, study design, aim of study, country, participant demographics (e.g. age range, gender), type of exercise exposure, sample size, main results, themes, sub-themes. Missing data was not requested from study authors.

2.7 Data synthesis

The mixed-method analysis benefited the qualitative data to inform on the perceived effects, meanwhile the quantitative data informed on the measured effects. Using meta-analysis was

not appropriate because of the heterogeneity of variation in types of subjects, tools, study designs, outcomes to physical activity among type-2 diabetes mellitus. Therefore, narrative synthesis for quantitative studies and thematic synthesis for qualitative studies was used in this review. The narrative synthesis was tabulated in a spread sheet to catch variables examined. Firstly, the characteristics of each quantitative study were categorised, then, were divided into different groups, each specific outcome physical activity involved. The findings of each study were exhibited and synthesised in order to see whether they had divergent or similar findings. A thematic synthesis of results from the qualitative studies was considered to investigate perceived barriers and facilitators towards physical activity among people among T2DM followed by a mix-method synthesis to combine the previous analysis. One reviewer (OO) managed the initial data synthesis which was then discussed with all reviewers.

3- Results

3.1 Study Selection

Overall, 1,078 articles were identified that are 237 articles via MEDLINE, 259 articles via PUBMED, 165 articles via CIHANL, 417 articles via Web of Science. After 260 duplicates were removed, 818 titles and abstracts were screened against the inclusion and exclusion criteria which posed the exclusion of 779 papers. The full texts of the remaining 39 citations were screened for eligibility, and 14 citations were considered ineligible because they did not meet the disease, subject, intervention and time criterion. A further 5 papers were recognised through screening of the reference lists of the relevant and including articles. In total, 30 studies, which comprised 11 qualitative, 18 quantitative studies, and mix-method study, convened the inclusion criteria and were included in this systematic review. Steps of database searches were presented in the PRISMA flow chart in the **Figure 1** present (Moher *et al.*, 2009).

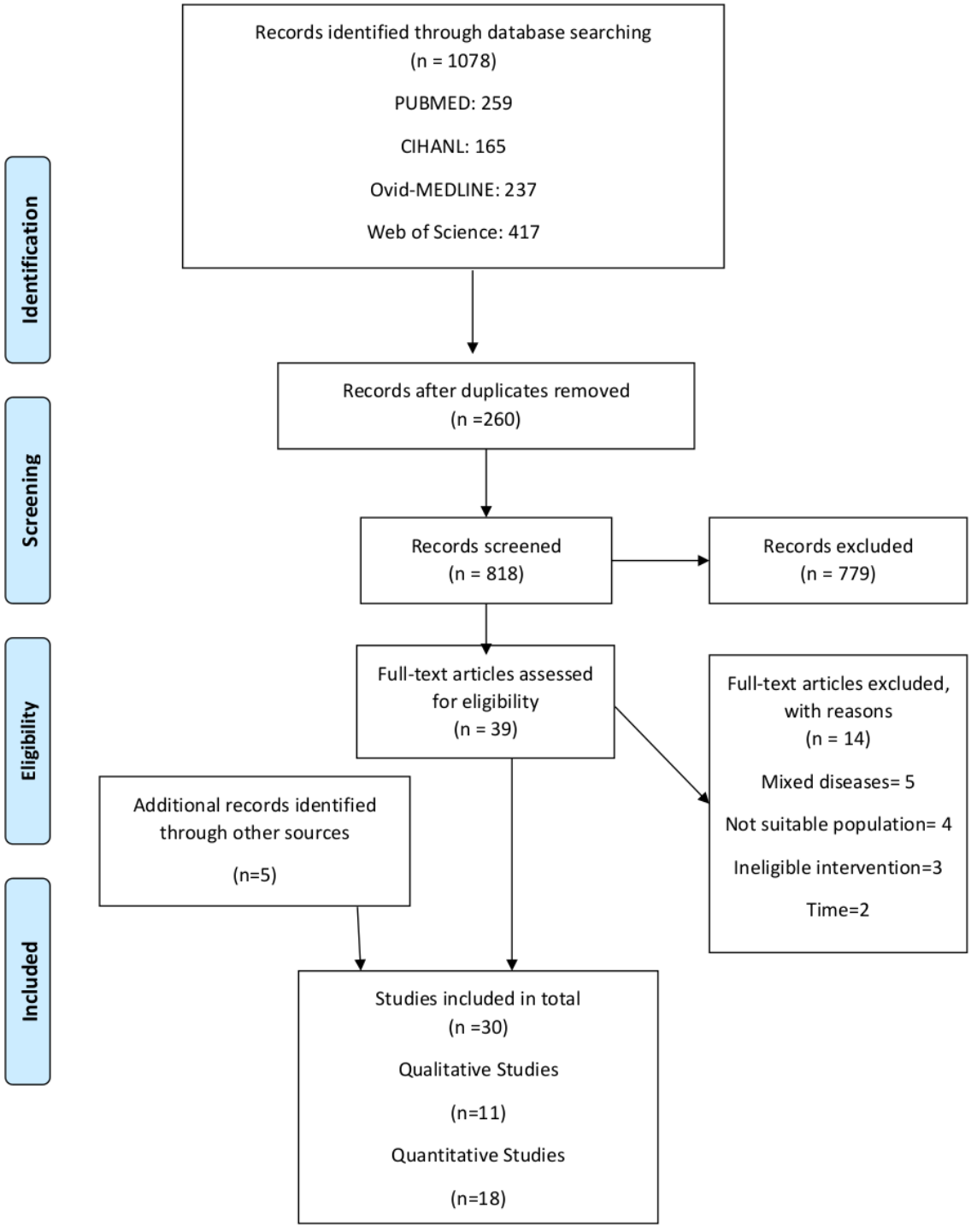


Figure 1: PRISMA flow chart

3.2 Study and participant characteristics

Data extraction was about: author name, year, country, participant's demographics and sample size, type of exercise, aim of study, and main results. The characteristics of studies were shown in **TABLE 4.**

Of the 30 eligible studies recognised, the included studies were conducted in the following 19 countries: the United States (n= 5), India (n= 3), Canada (n=3), Denmark (n=2), Belgium (n=2), Indonesia (n= 2), Scotland (n= 1), Nigeria (n= 1), Ethiopia (n= 1), Jamaica (n= 1), Nepal (n= 1), Norway (n= 1), South Africa (n= 1), Spain (n= 1), Finland (n= 1), Saudi Arabia (n=1), Oman (n=1), Viet Nam (n=1), Sri Lanka (n= 1). The most commonly used methodological design was quantitative (18 studies), and 11 studies were qualitative and only one study was designed with mix methods.

Studies were published between 2009 and 2020. The sample size in the included studies ranged from 10 to 2,866 participants. The total population with T2DM was 7,884 in thirty studies. The total number and percentages of males and females were 4,359 (55%) and 3,016 (45%) respectively in the thirty studies. In one study, the total of sample size was 509; 122 of them were individuals with T2DM (Adeniyi et al., 2012). This study did not account for the number of females and males with T2DM according to the total of sample size. Thus, the number of females and males in this cross-sectional study were not added to the number of females and males in this review.

The majority of studies focused on barriers and facilitators factors (n=14). The other focused only on motivational factors (n= 4), and barriers (n=6). The three of them concentrated on the effect of physical environment on perceived barriers and facilitators to physical activity (n= 5), and the effect of changes in psychosocial variables in physical activity (n= 1). The highest mean age of study participants was 66.8±5.3 years (Rachmah et al., 2019), and the lowest age range 50-21 (Miller, Marolen, and Beech, 2010). The highest diabetes duration was 11.87 years (Van Dyck *et al.,* 2011), and the lowest diabetes duration 2 years (Booth *et al.,* 2013). However, diabetes duration in the twelve studies was not stated. The highest mean body mass index (BMI) was 35.9 kg/m2 (Miller, Marolen, and Beech, 2010, and lowest mean BMI was 22.8 kg/m2 (Gizaw *et al.,* 2017) but the mean BMI was not defined in fifteen studies.

TABLE 4: Characteristics of Studies

Qualitative Studies					
Autor	Study design	Participant demographics and sample size	Type of exercise	Aim of Study	Main results/ Themes
Advika, Idiculla, Kumari, 2017 **Country:** India (Bengaluru)	Interview	**Sample size:** 13 people with T2DM **Gender:** Males: 7 (54%) Females: 6 (46%) **Age:** 40-80 years Ages- (Males, Females): 40-50 years old = 4 (4,0) 50-60 years old= 6 (3,3) 60-70 years old= 2 (0,2) 70-80 years old= 1 (0,1) **Diabetes duration:** ≥ 1 years	General expression (physical exercise)	To describe the factors which (i) Facilitated and (ii) hindered the practice of regular exercise in patients with Type 2 diabetes practice of regular exercise in patients with Type 2 diabetes	Main barriers: Lack of time, obligations to others, inability to link exercise with blood sugar control, lack of perception of obesity as a health issue, inadequate emphasis by physicians, social/cultural issues, lack of infrastructure, and physical restriction. Facilitating factors: awareness regarding the benefits of exercise and complications linked with diabetes, positive family support, and emphasis by nursing staff emerged

		BMI/Mean: NB			
Arovah, Kushartanti, Washigton, Heesch, 2019 **Country:** Indonesia	Focus group	**Sample size:** 28 **Gender:** **Males:** 14 (50%) (active men's group: 8; inactive men's group: 6) **Females:** 14 (50%) (active women's group: 8; inactive women's group: 6). **Age:** **Mean age:** 62.8± 5.4 years. Mean age for physically active men and women (66.5 ± 4.6 vs. 61.6 ± 5.1 years respectively). Mean age for physically inactive men and women (62.8 ± 2.3 vs. 59.6 ± 6.8 years	Walking, Physical activity programs, bicycling, stair climbing, and breathing exercises	To identify the enablers and barriers to T2DM patients' physical activity as well as their preferences and in experiences with physical activity program, with a view to developing future programs that are best suited to these patients' needs and preferences.	Main barriers; lack of enjoyment, the absence of knowledge about appropriate activities for T2DM, a shortage of time. Facilitating factors: to be physically active for the health benefits and for social interaction.

		respectively). **Diabetes duration:** NB **BMI/Mean:** NB			
Booth et al., 2013 **Country:** USA	Focus group	**Sample size:** 42 people with T2DM **Gender:** Males: 26 (62%) Females: 16 (38%) **Age**: 45-75 **Mean age**: 60.2±7.5 **Diabetes duration:** within the previous 2 years **BMI/Mean:** NB	General expression (physical exercise)	To explore the views of individuals recently diagnosed with T2DM in relation to self-management of dietary intake and physical activity, and to compare these with the views of health professionals (HPs).	Main barriers: co-morbidities, poor weather, traffic, safety concerns, lack of pleasant places to walk. Facilitating factors: less weight
Casey et al., 2010	Focus group	**Sample size:** 16 people with T2DM **Gender:**	Supervised education program	To assess barriers and facilitators of participation in a supervised exercise programme, and adherence	Main barriers: co-morbidities, time constraints, inclement weather, absence of support supervision, unsafe neighbourhoods, cultural

Country Canada		Males: 9 (56.25%) Females: 7 (43.75 %) **Age:** 39-65 **Mean age:** 52.5 **Diabetes duration**: 3.5 (0.7-13 years) **BMI/Mean:** NB		to exercise after programme completion.	expectations. Facilitating factors: family support
Lidegaard, et al.,2016 **Country:** Denmark	Focus group	**Sample size:** 28 people with T2DM **Gender:** Males: 15 (53%) Females: 13 (47%) **Age:** 39-71 years **Mean age:** 59.4 **Diabetes duration**: 8.5± 7.2 years	General expression (physical exercise)	To explore barriers and motivators for physical activity in a group of overweight and obese individuals with dysregulated T2DM.	Main barriers: the body as a barrier to physical activity because of functional limitations; 2) logistical challenges, including lack of time and awareness of where to exercise in the local area; 3) being physically active with others, providing a sense of mutual commitment and enjoyment; and 4) goal-setting and self-tracking, which was seen as an opportunity to track

		BIM/ Mean: 34.4 ±5.0 kg/m2			physical improvement over time.
Medagama and Galgomuwa, 2018 **Country:** Sri Lanka	Interviews	**Sample size:** 40 people with T2DM **Gender:** Males: 11 (27%) Females: 29 (73%) **Age:** **Mean age:** 55.4± 8.9 **Diabetes duration**: 8.5± 6.8 years **BIM/ Mean:** 25.8kg/m2	General expression (physical exercise)	To explore the contextual reasons that limited physical activity among type 2 diabetic patients living in a rural community.	Health related issues, lifestyle and time management, environmental and social factors like social embarrassment, prioritizing household activities over PA were important factors that limited PA. Most stated that the concept of exercising was alien to their culture and lifestyle.
Miller, Marolen, & Beech, 2010	Moderator-led focus group	**Sample size:** 31 people with T2DM **Gender:** Males: 0	"Physical activity" was associated with activities such as mowing the lawn	To evaluate Motivational interviewing (MI) perceptions among rural African American women with Type 2 diabetes prior to	Patients regarded the MI consultation as an effective health communication, but the patient-centeredness of the approach was negatively perceived. Compared to MI, patients agreed that

Country: USA		Females: 31 (100%) **Age:** 21-50 **Mean age:** NB **Diabetes duration:** 10.2 ±4.9 years **BMI/Mean:** 35.9 ±8.9	or doing household chores. Activities such as biking, and dancing were associated with "exercise".	a physical activity intervention.	more traditional paternalistic approaches (i.e. physician-led interactions) were more representative of "good counselling" and more familiar to them.
Park et al., 2020 **Country:** USA	An emergent	**Sample size:** 63 people with T2DM, care giver, and friends **Gender:** Males: 24 (37) Females: 39 (63) **Age**: being≥ 18 years **Mean age:** NB **Diabetes duration:** NB	General expression (physical exercise)	To explore the influences of the neighbourhood environment on physical activity (PA) among people living with T2DM in a community with limited resources	Levels of PA were strongly limited by neighbourhood insecurity and a lack of recreational facilities in the neighbourhood. People with T2DM and physical/mobility disabilities were more affected by the neighbourhood environment than those without disabilities, particularly due to perceived safety concerns and social stigma.

		BMI/Mean: NB			
Peel et al., 2010 **Country:** Scotland	Longitudinal, repeat in-depth interview	**Sample size:** 20 people with T2DM **Gender:** Males: 11 (55%) Females: 9 (45%) **Age**: 40-over 70 years old **Mean age**: 40-49= 5, 50-59=1, 60-69=11, ≥70=3 **Diabetes duration:** over 4 years following clinical diagnosis. **BMI/Mean:** NB	Walking with a dog	To explore type 2 diabetes patients' talk about implementing and sustaining physical activity.	Aside from walking, physical activities which were adopted tended to attenuate over time. Patients' accounts revealed how walking a dog assisted this kind of activity maintenance over time. Three main themes are highlighted in the analysis: 1) incidental walking; 2) incremental physical activity gains; and 3) augmenting physical activity maintenance. The problems arising from walking without a dog (for example, lack of motivation) are also examined.

Tulloch et al., 2013 **Country:** Canada	Interview	**Sample size:** 28 people with T2DM **Gender:** Males: 20 (71%) Females: 8 (29%) **Age:** 39-70 **Mean age**: 55.7 **Diabetes duration**: at least 6 months **BMI/Mean:** 35.0 km m2	Aerobic, resistance, combine aerobic and resistance.	To determine facilitators and barriers to exercise at multiple time points while enrolled in a randomized exercise trial including aerobic, resistance or combined exercise.	Main barriers: Experiencing illness or injury, work commitments and inclement weather Facilitators factors: social support from family and the trainer, future health benefits, a sense of well-being and perceived fitness improvements
Walker, Valentiner, & Langberg, 2018 **Country:** Denmark	Semi-structured, individual, qualitative Interview	**Sample size**: 10 people with T2DM **Gender:** Males: 8 (80%) Females: 2 (20%)	Walking	To explore motivational factors for initiating, implementing, and maintaining physical activity following a rehabilitation program for patients with type 2 diabetes mellitus.	Successful behavioural change was characterized by transfer of commitment to a new structure in everyday life, which also honoured the request for autonomy. Feeling capable of participating in physical activity was facilitated through knowledge, practical experience, and

		Age: 41-70 **Mean age:** 58 **Diabetes duration**: NB **BMI/Mean:** NB			progress and considered motivational, whereas lack of progress extinguished motivation. Finally, enjoyment of the activity was determining for long-term maintenance of physical activity behaviour.
Quantitative Studies					
Author	Study design	Participant demographics and sample size	Type of exercise	Aim of Study	Main results/ Themes
Adeniyi, Idowu, Ogwumike, Adeniyi, 2012 **Country:** South-western	Cross-sectional study	**Sample size:** 509 T2DM: 122 (24%) Hypertensive patients: 212 (41.6%) Stroke patients: 104 (20.4%) Patients with a combination of two or three of these disorders:	General expression (physical exercise)	To assess physical activity level, self-efficacy, social support and perceived barriers of the participants	The odds of having low physical activity was highest in those with low social support for Type 2 Diabetes (OR=3.95, 95% CI=3.13-5.24) Statistical test showed that physical activity level was significantly associated ($p<0.05$) with each of self-efficacy ($p = 0.04$), social support ($p <0.0001$) and perceived barriers ($p =$

Nigeria		71 (13.9%) **Gender:** Males: 269 (52.8%) Females: 240 (48.2%) **Age:** 35-80 years **Mean age**: NB **Diabetes duration:** NB **BMI/Mean:** NB			0.02).
Alghafri et al., 2017 **Country:** Oman	Cross-sectional survey	**Sample size:** 305 **Gender:** Males: 175 (57.4%) Females: 130 (42.6%) **Age:** **Mean age**: 57± 10.8 **Diabetes duration:** 2 years and	General expression (physical exercise)	To identify barriers to performing leisure time physical activity and explore differences based on gender, age, marital status, employment, education, income and perceived stages of change in physical activity in adults with type 2	Lack of willpower (44.4%), lack of resources (30.5%) and lack of social support (29.2%) were the most frequently reported barriers. Using $\chi 2$ test, lack of willpower was significantly different in individuals with low versus high income (54.2%vs40%, P=0.002) and in those reporting inactive versus active stages

		more **BMI/Mean:** 31.0 (6.0) kg/m2 Overweight: 118 (39%) Obese: 153 (50%)		diabetes in Oman.	of change for physical activity (50.7%vs34.7%, P=0.029), lack of resources was significantly different in those with low versus high income (40%vs24.3%, P=0.004) and married versus unmarried (33.8%vs18.5%, P=0.018). Lack of social support was significant in females versus males (35.4%vs20.8%, P=0.005)
Alzahrani et al., 2019 **Country:** Saudi Arabia	Cross-sectional	**Sample size:** 247 people with T2DM **Gender:** Males: 92 (38 %) Females: 155 (62 %) **Age:** 25-75 years **Mean age:** 56±9 years **Diabetes duration:** NB **BMI/Mean:** NB	General expression (physical exercise)	To evaluate the level of PA and the barriers toward practicing regular PA among patients with type 2 diabetes mellitus (T2DM) attending primary healthcare centers (PHCs) in Jeddah during 2018.	The prevalence of physical inactivity was found to be 38.4%. Males and females composed 40% and 37.4% of the participants, respectively. Lack of social support, lack of energy, fear of injury, and lack of skills were identified as significant barriers to physical activity according to the level of physical activity.

Anjana et al., 2015 **Country:** India	Cross-sectional study	**Sample size:** 1281 people with T2DM **Gender:** Males: 816 (63.7%) Females: 415 (36.3%) **Age:** 20-65 Mean age: NB Non-exercisers: 43.4 ± 9.2 Exercisers: 46.9 ±9.1 **Diabetes duration**: NB **BMI/Mean:** No-exercisers: Overweight: 438 (45.1%) Obese: 447 (46%) Exercisers:	Type of exercise performed walking (85.1%), followed by yoga (22.3%), cycling (10.4%) and running (9.1%).	To describe the patterns of exercise and the perceived benefits and barriers to exercise in an urban south Indian population	Physical activity was highest in those with low social support for Type 2 Diabetes (OR=3.95, 95% CI=3.13-5.24) Statistical test showed that physical activity level was significantly associated ($p<0.05$) with each of self-efficacy ($p = 0.04$), social support ($p <0.0001$) and perceived barriers ($p = 0.02$).

		Overweight: 159 (51.5%) Obese: 123 (39.8%)			
Erickson, 2013 **Country:** USA	A descriptive Cross-sectional	**Sample size:** 75 people with T2DM **Gender:** Males: 58 (77.3%) Female: 17 (22.7%) **Age:** **Mean age:** 58.66 ± 4.182 **Diabetes duration:** NB **BMI/Mean**: 34.1 ± 8.16 Normal: 6 (8%) Overweight: 19 (25%) Obese: 50 (66.7%)	General physical activity (walking the dog, vacuuming, raking leaves) and specific exercise swimming, aerobic exercise, walking, or biking	To explore the level of physical activity, barriers to physical activity, and strategies used to meet physical activity goals in people with T2DM.	Results of general physical activity frequency include 21.3% of participants exercising 2 days or fewer, 32% exercising 3 to 5 days, and 46.7% exercising 6 or 7 days per week. Results of specific activity frequency include 31.1% exercising 2 days or fewer, 35.2% exercising 3 to 5 days, and 33.8% exercising 6 or 7 days per week. Participants who were active reported fewer barriers to physical activity and chose to work on more self-care areas to control their diabetes than did those participants who were inactive.

Gizaw et al., 2017 **Country:** Southwest Ethiopia	A facility-based cross-sectional	**Sample size:** 319 people with T2DM **Gender:** Males: 225 (70.5%) Females: 94 (29.5%) **Age:** 42-65 years **Mean age:** 55.3 ± 5.7 **Diabetes duration:** 4.9 ±2.3 years **BMI/Mean:** 22.8 ± 2.8 Normal weight: 239 (74.9%) Obese: 68 (21.3%)	General expression (physical exercise) Such as (running, jogging, going to the gym, or brisk walking)	To identify predictors of physical activity among DMT-2 patients attending	Two hundred seventy-nine (87.5) of the respondents had adequate general knowledge of diabetes and 31.7% of the respondents had adequate general knowledge of physical activity. The likelihood of engaging in the recommended physical activity was associated with perceived barrier (odds ratio [OR]=0.58, 95% confidence interval, CI [0.56, 0.67]; p<0.000), perceived self-efficacy (OR=1.33, 95% CI [1.12, 1.57] p<0.001) and perceived benefit (OR=1.16 (95% CI [1.03, 1.29] p<0.000)

Gordon & Nelson, 2018 **Country:** Jamaica	Cross-sectional	**Sample size:** 194 people with T2DM **Gender:** Males: 56 (28.9) Females: 138 (71.1%) **Age:** 18 years old and over **Mean age:** 57.5 **Diabetes duration:** < 1 year: 21 (10.8%) 1-10 years: 86 (44.3%) >10 years: 87 (44.8%) **BMI/Mean:** NB	General expression (physical exercise)	To determine the factors associated with physical activity level in Jamaicans with type 2 diabetes.	38.7% was low active, 33.5% was moderately active and 26% was highly active Main barriers: perception of exercise as hard work, tiring, fatiguing.
Greef et al., 2011	Cross-sectional	**Sample size:**133 people with T2DM **Gender:**	General expression	To investigate the associations of physical environmental factors with objectively assessed and self-	The contribution of physical environmental factors remained significant for most physical activity (PA) measures after taking into

Country: Belgium		Males: 91 (68.4%) Females: 42 (31.6%) **Age:** 35-80 years **Mean age:** 61.4 ± 8.4 **Diabetes duration:** <5 years: 33 (24.8%) ≥5 years: 100 (75.2%) **BMI/Mean:** Male: 29.9 ±3.3 Female: 30.6 ± 3.7	(physical exercise)	reported PA in type 2 diabetes patients	account the variance explained by psychosocial factors (explained variance from 4% to 10%), except for step counts and recreational walking. Physical environmental factors could be important correlates of PA in type 2 diabetes patients, even beyond the contribution of sociodemographic and psychosocial variables.
Kadariye et al., 2018 **Country:** Nepal	Cross-sectional	**Sample size:** 270 people with T2DM **Gender:** Males: 167 (62%) Females: 103 (38%) **Age:** 30-70 years	General expression (physical exercise)	To explore the prevalence of physical activity and factors that promote and hinder the behaviour among urban residing diabetic patients from Nepal	52% were moderately active and 28% highly active. Travel and work-related activities were the major contributors. Main barriers: Family responsibilities, busy schedule and family

		Mean age: 53 **Diabetes duration**: 3 months to 34 years The average:7.5 years **BMI/Mean:** NB			discouragement.
Oftedal, Bru, & Karlsen, 2011 **Country:** Norway	Cross-sectional design	**Sample size:** 425 people with T2DM **Gender:** **Males:** 229 (53.9%) **Females:** 196 (46.1%) **Age:** 30-70 **Mean age:** 58.2 ± 8.6 **Diabetes duration:** 8.1 ±6.1 years **BMI/Mean:** 29.7 ± 5.3	General expression (physical exercise)	The aim of this study was to investigate diet and exercise management and how indicators of intrinsic motivation such as ability expectations and values are associated with diet and exercise management among adults with T2DM	Reported diet management was more in accordance with recommendations than reported exercise management. Yet results indicated equally high ability expectations and positive values for exercise and diet management. Moreover, results demonstrated that ability expectations and values explained more variance in exercise (21.6%) than in diet management (7.6%).
Pati et al.,	Cross-sectional,	**Sample size:** 321 people with	Yoga, outdoors sports,	To identify patterns and preferences of physical	Almost two-thirds of patients (59%) were reported performing PA

2019 **Country:** India	facility-based study	T2DM **Gender:** Males: 204 (64%) Females: 117 (36%) **Age:** 20-60 and over **Mean age:** 51 ± 12.8 **Diabetes duration:** NB **BMI/Mean:** Underweight: 4 (1.25%) Normal: 136 (42.3%) Overweight: 136 (42.3%) 0bese: 45 (14%)	gardening, cycling, jogging, walking	activity of T2D patients and explore perceived enablers and barriers for diabetes control.	frequently. Majority patients cited walking as the most preferred mode of PA (79%) with 41% performing PA daily. Main barriers: Lack of times, unwillingness Facilitator factors: Controlling diabetes, doctor's advice.
Shiriyedeve, Dlungwane,	An observational	**Sample size:** 169 people with T2DM	General expression	To assess the physical activity levels (PALs) and	There was a weak negative correlation between age and PAL (r = -0.085) and

& Tlou, 2019 **Country:** South Africa	cross-sectional	**Gender:** Males: 58 (34.3%) Females: 111 (65.7%) **Age:** 18-65 **Mean age**: 51 ± 13.3 **Diabetes duration**: NB **BMI/Mean:** Underweight: 3 (1.9%) Normal: 21 (13.1%) Overweight: 43 (26.9%) Obese: 93 (58.1%)	(physical exercise)	factors associated with physical activity in type 2 diabetes mellitus.	between sitting time (sedentary time) and PAL (-0.098). There was no statistical significant association between PAL and the following socio-demographic factors: sex, marital status, level of education, employment status, dwelling place and BMI. Main barriers: no place to exercise (8.8%) and no one to exercise with (8.7%). Facilitator factors: wanting to be healthy 73.3%, wanting to look good 66.9%, liking exercise 57.1% and wanting to lose weight 50.3%.
Rachmah et al., (2019) **Country:** Indonesia	Cross-sectional study	**Sample size:** 56 people with T2DM **Gender:** Males: 16 (28.6%)	General expression (physical	To investigate barriers to physical activity (PA), self-efficacy to overcome those barriers, and PA self-efficacy among elderly individuals	In total, 89.3% of participants had a low PA level and 58.9% had more than 3 hours of sedentary activity per day. Furthermore, 55.4% were obese and 14.3% were overweight. The mean

		Females: 40 (71.4%) **Age:** **Mean age**: 66.8±5.3 **Diabetes duration**: NB **BMI/Mean:** Underweight: 1 (1.8%) Normal: 16 (28.6%) Overweight: 8 (14.3%) Obese: 31 (55.4%)	exercise)	with diabetes in relation to BMI.	scores for PA self-efficacy and self-efficacy to overcome barriers were 59.1± 26.4 and 52.5±13.8, respectively. PA level was related to BMI
Thu et al., 2016 **Country:** Viet Nam	Cross-sectional analytic study	**Sample size:** 246 people with T2DM **Gender:** Males: 123 (50%) Females: 123 (50%) **Age**: 35-84 years **Mean age**: 56.93 ±11.48	General expression (physical exercise)	To explore the level of physical activity, and to predict personal characteristics, perceived susceptibility, perceived severity, perceived benefits, perceived barriers, and perceived self-efficacy on the physical activity of	Stepwise multiple regression analysis revealed that the mean score of physical activity was 2062.20 MET (Metabolic equivalent)-minutes per week (SD = 1168.45, range 0.00 – 5520.00), and it revealed that 11.4% of participants didn't have enough physical activity. It also indicated that only four variables (occupation of

		Diabetes duration: 4.58 ± 2.85 **BMI/Mean**: NB		people with type 2 diabetes mellitus.	labor, perceived susceptibility, perceived severity, and perceived self-efficacy) were significant predictors of physical activity. These variables accounted for about 20% (R2 = .20, p < .05) of the variability in PA.
Koponen, Simonsen & Suominen, 2017 **Country:** Finland	Survey	**Sample size:** 2866 people with T2DM **Gender:** Males: 1599 (56%) Females: 1267 (44%) **Age:** 27-75 **Mean age:** 63 ± 8 **Diabetes duration**: NB **BIM/ Mean**: NB	General expression (physical exercise)	To investigate whether the three central self-determination theory (SDT) variables (perceived autonomy support, autonomous motivation and self-care competence), were associated with engagement in physical activity (PA) among T2DM.	Perceived autonomy support (from one's physician) was associated with the patient's PA through autonomous motivation. This result is in line with SDT. Interventions for improved diabetes care should concentrate on supporting patients' autonomous motivation for PA. Internalizing the importance of good self-care seems to give sufficient energy to maintain a physically active lifestyle.
Dávila, 2010	Non-experimental, a descriptive	**Sample size:** 110 people with T2DM	Aerobic physical activity and resistance	To explore physical activity self-efficacy beliefs	This finding means that the higher the physical activity self-efficacy beliefs, the higher the physical activity level.

Country: Spain	correlational study	**Gender:** Males: 38 (34.5) Females: 72 (65.5) **Age:** 40-60 **Mean age**: 52.2 ± 5.6 years **Diabetes duration:** NB **BMI/Mean:** Normal (18.5-24.9): 8.2% Overweight (25.0-29.9): 27.3% Obese (30.0 and over): 64.5%	training	and outcome expectancies (perceived physical activity benefits and barriers) as possible factors associated with physical activity level in adults diagnosed with type 2 DM	No significant association was observed between outcome expectancies (perceived physical activity benefits) and physical activity level (rs =.09, p = .38). Main barriers: Physical activity causes tiredness (56.4%) and fatigue (54.6%). Exercising takes too much of my time (2.35); exercise is hard work for me (2.14) and places for me to exercise are too far away (2.03). Facilitator factors: exercising increases my level of physical fitness (3.80); exercising improves functioning of my cardiovascular system (3.79); exercise improves the way my body looks (3.67); exercise improves my mental health (3.64) and exercising makes me

					feel relaxed (3.61).
Dyck et al., 2011 **Country:** Belgium	Randomised Control Trail	**Sample size**: 92 people with T2DM **Gender:** Males: 63 (69%) Females: 29 (21%) **Age:** 35- 75 years **Mean age:** 62± 9 years **Diabetes duration**: 11.87 ± 9.66 **BMI/Mean:** 30.24 ± 2.62 kg/m2	General expression (physical exercise)	To examine mediation effects of changes in psychosocial variables on changes in physical activity in type 2 diabetes patients.	Post-intervention physical activity changes were mediated by coping with relapse, changes in social norm, and social modelling from family members (p≤0.05). One-year physical activity changes were mediated by coping with relapse, changes in social support from family and self-efficacy towards physical activity barriers (p≤0.05).
Sweet et al., 2009	Randomised control trail	**Sample size:** 234 people with T2DM	Aerobic, resistance, combine aerobic	To better understand the sequencing of motivational constructs that may	Results of this study extend our understanding of the motivational constructs involved in PA in the

Country: Canada		**Gender:** Males: 151 (64.5%) Females: 83 (35.5%) **Age**: 40-70 years **Mean age**: 53 **Diabetes duration**: NB **BMI/Mean**: NB	and resistance.	influence physical activity levels.	maintenance phase. This study has important theoretical implications in that it helps to organize and consolidate well-known correlates of PA by proposing a temporal relationship between them that could be tailored in interventions.
Mix-method Studies					
Sophia et al., 2018 **Country:** USA	A concurrent mix-method	**Sample size**: 100 people with T2DM **Gender:** Males: 53 (53%) Females: 47 (47%) **Age**: 26-92 **Mean age:** 63.01 ± 14.48	Aerobic exercise and strength training	To learn more about this population's knowledge of physical activity, the types and intensity levels performed, and the barriers to such activity.	Regarding types of physical activity, the most common were housekeeping, walking up stairs, and taking walking or stretching breaks every hour during the workday. Main barriers: insufficient education about physical

		Diabetes duration: 3.3 ± 6.64 **BMI/Mean**: Underweight: 2 (2%) Normal: 34 (34%) Overweight: 40 (40%) Obese: 22 (22%)			activity, health concerns about physical activity, and work-related barriers to physical activity

3.3 Quality assessment

The methodological quality assessment of included studies was conducted for each study by using MMAT scoring system (Pluye et al., 2011). Two studies were evaluated against randomised-control trial criteria, ten studies against non-randomised quantitative criteria, six studies against descriptive quantitative criteria. Eleven studies were evaluated against qualitative criteria, and one studies against mix-method criteria **(APPENDIX 3).** The methodological quality criteria of the MMAT were demonstrated in **TABLE 5.**

TABLE 5: The methodological quality criteria of the MMAT.

Table 2 Quality rating

Study designs	Methodological quality criteria
1. Qualitative	1.1. Are the sources of qualitative data (archives, documents, informants, observations) relevant to address the research question (objective)?
	1.2. Is the process for analyzing qualitative data relevant to address the research question (objective)?
	1.3. Is appropriate consideration given to how findings relate to the context, e.g., the setting, in which the data were collected?
	1.4. Is appropriate consideration given to how findings relate to researchers' influence, e.g., through their interactions with participants?
2. Quantitative randomized controlled (trials)	2.1. Is there a clear description of the randomization (or an appropriate sequence generation)?
	2.2. Is there a clear description of the allocation concealment (or blinding when applicable)?
	2.3. Are there complete outcome data (80% or above)?
	2.4. Is there low withdrawal/dropout (below 20%)?
3. Quantitative non-randomized	3.1. Are participants (organizations) recruited in a way that minimizes selection bias?
	3.2. Are measurements appropriate (clear origin, or validity known, or standard instrument; and absence of contamination between groups when appropriate) regarding the exposure/intervention and outcomes?
	3.3. In the groups being compared (exposed vs. non-exposed; with intervention vs. without; cases vs. controls), are the participants comparable, or do researchers take into account (control for) the difference between these groups?
	3.4. Are there complete outcome data (80% or above), and, when applicable, an acceptable response rate (60% or above), or an acceptable follow-up rate for cohort studies (depending on the duration of follow-up)?
4. Quantitative descriptive	4.1. Is the sampling strategy relevant to address the quantitative research question (quantitative aspect of the mixed methods question)?
	4.2. Is the sample representative of the population understudy?
	4.3. Are measurements appropriate (clear origin, or validity known, or standard instrument)?
	4.4. Is there an acceptable response rate (60% or above)?
5. Mixed methods	5.1. Is the mixed methods research design relevant to address the qualitative and quantitative research questions (or objectives), or the qualitative and quantitative aspects of the mixed methods question (or objective)?
	5.2. Is the integration of qualitative and quantitative data (or results*) relevant to address the research question (objective)?
	5.3. Is appropriate consideration given to the limitations associated with this integration, e.g., the divergence of qualitative and quantitative data (or results*) in a triangulation design?
	Criteria for the qualitative component (1.1 to 1.4), and appropriate criteria for the quantitative component (2.1 to 2.4, or 3.1 to 3.4, or 4.1 to 4.4), must be also applied

Mixed methods appraisal tool (MMAT) criteria

* These two items are not considered as double-barreled items since in mixed methods research, (1) there may be research questions (quantitative research) or research objectives (qualitative research), and (2) data may be integrated, and/or qualitative findings and quantitative results can be integrated

The methodological quality of the 30 studies was assessed from 25% to 100%. In the end of evaluations, thirteen studies were rated 100%, fourteen studies were rated 75%, one study was rated 50%, and two studies 25%. These scores were presented in **Table 6.** The predominance of the included qualitative studies (n= 9) were unsuccessful to identify the potential impact of the investigators' epistemology perspective in terms of study design. Three of the included qualitative (n= 3) failed to recognise the selection criteria of the participants. One qualitative (n= 1) study provided only data collection criteria. While the one of the randomised-control trials did not provide the criteria of only blinding to group allocation, the other randomised trial provided only one criterion. Seven of the studies using non-randomised control trials quantitative methodologies were completed all quality criteria with 100% score. Three non-randomised control trials did not achieve a clear explanation about dissimilation about groups. All quantitative descriptive methodologies achieved all quality criteria but one study did not provide a clear explanation of eligible criteria. One mix-method methodological design achieved all evaluation criteria. As a result, the complete quality of studies was high according to the MMAT version 2011 criteria.

Table 6: MMAT Scores of Studies

STUDY	MMAT Score
Qualitative Studies	
Advika, et al., 2017	***
Arovah et al., 2019	***
Booth et al., 2013	***
Casey et al., 2010	***
Lidegaard et al., 2016	***
Medagama & Galgomuwa, 2018	***
Miller et al., 2010	**
Park et al., 2020	***
Peel et al., 2010	***
Tulloch et al., 2013	****
Walker et al., 2018	*
Quantitative Studies	
RCTs	
Dyck et al., 2011	***
Sweet et al., 2009	*
Non-RCTs	
Adeniyi et al., 2012	***
Alghafri et al., 2017	***
Alzahrani et al.,2019	****
Anjana et al., 2015	****
Gizaw et al., 2017	****
Gordon et al., 2018	****
Greef et al., 2011	****
Oftedal et al., 2011	****
Pati et al., 2019	****
Thu et al., 2016	***
Descriptive Studies	
Davila, 2010	****
Erickson, 2013	****
Kadariye et al., 2018	****
Koponen et al., 2017	****
Rachmah et al., 2019	***
Shiriyedeve et al., 2019	***
Mix-Method Studies	
Sophia et al., 2018	****

*Scores vary from * (25%)—one criterion met, to **** (100%)—all criteria met*

3.4 Synthesis findings:

3.4.1 Narrative Synthesis of Quantitative Studies

The results of the included 18 quantitative studies and one mix-method study were tabulated in a spread sheet, and then these findings were narratively synthesised. Some results were not evaluated as exactly barrier or facilitator factors. Therefore, three main titles were constituted from studies; both barrier and facilitator factors, perceived facilitators, and perceived barriers.

The title of both barrier and facilitators was established from three domains: Social-demographic factors, self-efficiency, and social environment. The title of perceived facilitators was created from three domains: perceived individual benefits, perceived psychological benefits, and support of health professionals. The last title of perceived barriers consisted from four domains: individual barriers, environmental barriers, lack of time, and lack of knowledge. These titles were presented in the **TABLE 7**.

TABLE 7: Domains recognised from the narrative analysis

The barriers and facilitators of physical activity participation among people with T2DM.
Both Barrier and Facilitator Factors ***Domain 1- Social-demographic factors*** *-Age Factor* *-Gender Factor* *-Diabetes Duration* *-BMI Status* *-Education Level* *-Marital Status* *-Employment Status/ Income Level* ***Domain 2- Self efficacy*** ***Domain 3- Social Environment*** *-Social Supportive Environment* *-Social Discouraging Environment* *-Social Ineffective Environment*

Perceived Facilitators ***Domain 1- Perceived Individual Benefits*** ***Domain 2- Perceived Psychological Benefits*** ***Domain 3- Support of Health Professionals***
Perceived Barriers ***Domain 1- Perceived Individual Barriers*** ***Domain 2- Environmental Barriers*** ***Domain 3- Lack of Resource*** ***Domain 4- Lack of Time*** ***Domain 5- Lack of Knowledge***

3.4.1.1 Both Barrier and Facilitator Factors

Domain 1- Social Demographic Factors:

In this domain seven themes relating to individual status of participants: age, gender, diabetes duration, BMI status, education level, marital status, and employment status/ income level.

Theme 1-Age Factor

Eight studies supported that older people had a more sedentary life (Alzahrani et al., 2018; Davila, 2010; Gizaw et al., 2017; Gordon and Nelson, 2018; Koponen, Simonsen, and Suominen 2016; Shriyedeve, Dlungwane, and Tlou, 2019; Pati et al., 2018). For example, while participants from 51-60 years of age reported a median of 60 minutes/week of moderate to vigorous physical activity and participants between 40-50 years of age reported a median of 90 minutes/week (Davila, 2010). Conversely, Anjana et al., (2015) reported that physically active people were older than physically inactive people. This finding was dependent on that older people had more spare time in order to exercise due to having retired from active work or being engaged in less time-consuming. However, Anjana et al., (2015) needed future studies to support their findings.

Theme 2- Gender Factor

Six studies had stressed that females tend to live more sedentary life than men (Alzahrani et al., 2019; Davila, 2010; Erikson, 2013; Gordon and Nelson, 2018; Kadariye *et al.,* 2018; Pati *et al.,* 2018). Davila (2010) defined that while men participated a median of 120 minutes/ week of moderate to vigorous physical activity, females participated 60 minutes/ week. Gordon and Nelson, (2018) reported that females were significantly less active than men (42.3% and 36.4% respectively, p= 0.150). In the study with the total of 270 participants of Kadariye et al., (2018) demonstrated that the female participants had an average sedentary time of 307 minutes per day compared to 257 minutes per day among their males counterparts ($p<0.05$). Pati et al., (2018) documented that 54% females (n=63/117) practiced physical activity compared to 62% males (n=127/204). On the other hand, Shriyedeve, Dlungwane, and Tlou, (2019), Sweet et al., (2009) and Leelukkanaveera and Laway, (2016) did not reported any statistical substantial association between sex and the level of physical activity.

Theme 3- Diabetes Duration

Kadariye et al., (2018) considered that people who had been diagnosed with T2DM between 2 years and more had lower physical activity level than those who had been diagnosed between 6 months and less than. Pati et al., (2018) indicated that three-fourths active participants started exercising after being diagnosed with T2DM.

Theme 4- BMI Status

Four studies indicated that low physical activity level was observed more among the overweight or obese participants (Anjana et al., 2015; Gizaw et al., 2017; De Greef et al., 2011; Pati et al., 2018). However, Shriyedeve, Dlungwane, and Tlou, (2019) and Davila, (2010) did not reflect any important association between physical activity level and BMI ($p > 0.05$). Gizaw et al., (2017) defined that although BMI status had an effect on individual physical activity behaviour, BMI had no statistically important effect on physical activity. Davila, (2010) stated that while there were not significant differences in perceived physical activity benefits by age and gender groups, the differences in perceived PA benefits between BMI groups were important. For example, people with obesity had substantially lower perceived benefits than people with normal weight ($p=0.05$) (Davila, 2010).

Theme 5- Education Level

Some studies reported that there was a positive association between high education level and increased physical activity level (Algrafri et al., 2017; Anjana et al., 2015; Erickson, 2013; Kadariye et al., 2018; Pati et al., 2018). For example, Kadariye et al., (2018) stated that the odds of high PA among those with secondary and primary education compared to those who were illiterate were 1.97 ($p>0.05$) and 2.05 ($p>0.05$) respectively, and for moderate PA were 1.86 ($p>0.05$) and 1.90 ($p>0.05$). However, some studies reported that there was not any association between education level and PA level (Gizaw et al., 2017; Gordon and Nelson, 2018; Shriyedeve, Dlungwane, and Tlou, 2019; Leelukkanaveera and Laway, (2016).

Theme 6- Marital Status

Nearly all studies evaluated the marital status of participants, only two studies explained the result of evaluation that there was not an association between marital status and physical activity level (Alzahrani et al., 2019; Shriyedeve, Dlungwane, and Tlou, 2019).

Theme 7- Employment Status/ Income level

One study stressed that more those who were unemployed were physically inactive compared to those employed (Gordon and Nelson, 2018). People having high income had more performing physical activity habits than those of low income (Algrafri et al., 2017; Anjana et al., 2015; Davila, 2010; Gizaw et al., 2017).). In the two studies, nearly 75% of the study participants among the total of 1,391 participants had the habit of exercise doing less than 150 min of exercise per week (Anjana et al., 2015; Davila, 2010). On the other hand, Shriyedeve, Dlungwane, and Tlou, (2019) and Leelukkanaveera and Laway, (2016) emphasised that there was not any association between PA level and employment and the level of income.

Domain 2- Self-efficacy: This domain was related to the effect of the level of self- efficacy on PA.

Many studies mentioned the importance of self-efficacy on PA for people with T2DM. The lower the physical activity self-efficacy belief was associated with the lower the PA level, and also the higher the physical activity self-efficacy belief was associated with the higher the physical activity self-efficacy beliefs (Adeniye et al., 2012; Alzahrani et al., 2019; Davila, 2010; Gizaw et al., 2017; Rachmah et al., 2019; Sweet et al., 2009; Leelukkanaveera and Laway, 2016).

Davila, (2010) defined that the correlation between physical activity, self-efficacy belief and perceived physical activity barriers were important, moderate and negative ($r=-.40$, $p < .001$). Gizaw et al., (2017) defined that self-efficacy (OR= 1.33, 95% CI [1.12, 1.57] $p < .001$) had a significant factor in applying with $p < .05$ variables advised PA. There was a significant association between self-efficacy level and the PA level of the subjects ($p=0.001$) (Rachmah et al., 2019). Sweet et al., (2009) predicted that barrier self-efficacy considerably and positively affected firstly 12-month PA ($\beta=0.137$, $p < .001$), barrier self-efficacy considerably affected autonomous motivation ($\beta=0.270$, $p <.001$), and when autonomous motivation and barrier self-efficacy were included in the estimate, autonomous motivation was considerably related to 12-

month PA (β= 0.156, p < .01). The barrier self-efficacy and 12-month PA association was non important (β= .095, p>. 10) Gizaw et al., (2017). Van Dyck et al., (2011) found also that there was not a significant association between self-efficacy and barriers/ benefits (p>. 10).

Domain 3 - Social Environment: This domain explains that the social environment was perceived as a supportive factor, discouraging factor, or ineffective factor to being PA among T2DM participants. This domain comprised three themes.

Theme 1- Social Supportive Environment

Social environment was a supportive factor in three studies (Alzahrani et al., 2019; Kadariye and Aro, 2018; Pati et al., 2018; Shriyedeve, Dlungwane, and Tlou, 2019). Peer support or connections with others were perceived as a supportive factor. For example, Shriyedeve, Dlungwane, and Tlou, (2019) defined that the reason for not engaging exercise of 8.7% diabetes people was no exercise with one. People with the perception that PA provides change to interact with others were 1.54 times more probably to have high PA (OR = 1.54, CI: 0.80–2.97) and 2.28 times more probably to have moderate PA (OR = 2.28, CI: 1.25–4.15) (Kadariye and Aro, 2018). Pati et al., (2018) highlighted that family and friend's recommendations along with company were an important supportive factor in having an active life for people with T2DM.

Theme 2- Social Discouraging Environment

Social environment was identified as an unsupportive/discouraging factor by following studies Adeniyi et al., 2012; Alghafri et al., 2017; Eickson, 2013; Gordon and Nelson, 2018; Kadariye and Aro, 2018.

Kadariye and Aro, (2018) defined that diabetes people with the feeling that spouse or family discouraged them from being physically active, the odds of PA were indicated to decrease the odds of being high physical activity were 0.69 and of having moderate physical activity were 0.66 (p>0.05). Gordon and Nelson, (2018) reported that 18% of individuals with diabetes said that my spouse does not encourage me to be physically active. The lowest mean (1.17) was "I am discouraged from participating in physical activity by others'' (Erickson, 2013). Adeniyi et al., (2012) reported that low social support rose nearly four times the risk of having low PA in people with T2DM (OR = 3.95, 95% CI = 3.13-5.24.

Theme 3- Social Ineffective Environment

Social environment was an ineffective factor to being PA in the one study (Van Dyck et al., 2011).

The one study reported that social support from friends or doctors did not affect the level of PA (p> .10) Van Dyck et al., (2011).

3.4.1.2 Perceived Facilitators

Domain 1- Perceived Individual Benefits: This domain was related to the perceived benefits of exercise on health.

A majority of both active participants and inactive participants said that they strongly agreed or agreed to most of the listed benefits of performing exercise (Shriyedeve, Dlungwane, and Tlou, 2019; Gordon and Nelson, 2018; Kadariye et al., 2018; Pati et al., 2018; Gizaw et al., 2017; Koponen, Simonsen, and Suominen 2016; Anjana et al., 2015; Davila, 2010). Davila, (2010) reported that perceived physical activity benefits were a median of 102.5 and a range from 68-116 points in the non-experimental and descriptive correlational study. Exercising increases my level of physical fitness (3.80); exercising improves the functioning of my cardiovascular system (3.79); and exercise improves the way my body looks (3.67) (Davila, 2010). Gizaw et al., (2017) stated that 312 (97.8%) among the total of 319 participants responded that it is possible to control diabetes by engaging in physical activity.

In the study of Kadariye and Aro (2018) reported that nearly 20% of their participants were low-active physically active. They reported that participants in their cross-sectional perception that exercising provides benefit in sleep better at night, decreases my fatigue, prevents heart attack, and keeps having high blood pressure (Kadariye and Aro, 2018). They also revealed that 63% of participants thought that they had more the risk of living with diabetes complications. These factors might have performed as reinforcements in the participants' approach to PA (Kadariye and Aro, 2018). Moreover, they defined that the individual with diabetes were 1.73 times more probably to have moderate PA (OR= 1.73, Cl: 1.05-2.85) and 1.78 times more probably to have high PA (OR= 1.78, Cl: 1.02-3.11) with the benefit perception that PA performances as a means of preventive health (Kadariye and Aro, 2018). Shriyedeve, Dlungwane, and Tlou, (2019)

demonstrated that most participants were significantly motivated to engage in PA by willing to be healthy 73.3%, willing to be fit 66.6%,enjoying exercise 57.1%, and willing to lose weight 50.3%.

Domain 2- Perceived Psychological Benefits: This domain identifies the psychological benefits of physical exercise determined by participants.

A major of active felt that exercise improved mental health and decrease stress as compared to inactive (Anjana et al., 2015; Davila, 2010; Kadariye and Aro, 2018; Koponen, Simonsen, and Suominen 2016; Oftedal, Bru, & Karlsen, 2011; Pati et al., 2019). Koponen, Simonsen, and Suominen (2016) reported that the four variables measuring positive personality orientation or mental health were associated strongly with each other, that is, sense of coherence (.58, $p < .001$), energy correlated with emotional well-being (.78, $p < .001$). Person correlations between diagnosed depression, sense of coherence, emotional well-being were 10 ($p < .001$), 14 ($p < .001$) and 15 ($p < .001$) respectively. Participants felt that exercise improves my mental health (3.64) and exercising makes me feel relaxed (3.61) (Davila, 2010).

Domain 3- Support of Health Professionals: This domain explains the role and contribution of a health professional on the increasing of PA among T2DM participants.

Health professionals with the support of proper consultation and individualized prescription and by encouraging and monitoring to PA improve people with T2DM to transition and progress gradually in an exercise in order to overcome feelings of excessive tiredness (Gizaw et al., 2017; Gordon and Nelson, 2018; Kadariye and Aro, 2018; Pati et al., 2018; Shopia et al., 2018). However, in the only one study, it was stated that general practitioners did not provide a contribution to increase of PA ($p > .10$) (Van Dyck et al. 2011).

3.4.1.3 Perceived Barriers

Domain 1- Individual Barriers: This domain is related to the individual reasons of low level PA determined by the participant.

The perceived individual barriers to exercise among in many study population were ''exercise is tiring'', ''exercise is fatiguing'', and ''exercise is hard work'' (Anjana et al., 2015; Davila et al., 2010; Erickson, 2013; Gordon and Nelson, 2018; Pati et al., 2019). Davila, (2010) depicted that a high rate of the sample expressed that they agreed or strongly agreed that PA poses fatigue (54.6%) and tiredness (56.4%). Gordon and Nelson, (2018) reported that the rate of people who think exercise causes tiredness, and fatigue were 50% and 26.3% respectively.

The one study found that many participants did not participate in PA due to the fact that PA could cause to hypoglycaemia, particularly, in those individuals who take oral agents or in those individuals exercising at the peak time of insulin, such as meglitinides ad sulfonylureas, which stimulate the pancreas to secrete insulin (Erickson, 2013). Alzahrani et al., (2019) and Alghafri et al., (2017) also reported ''the fear of injury'' as a barrier.

Domain 2- Environmental barriers: This domain is related to the environmental reasons of low level PA determined by the participant.

The perceived environmental barriers to exercise among in many sample were the lack of safe road and places, lower availability and quality of walking infrastructure, and places for exercising being too far away (Anjan et al., 2015; Davila et al., 2010; Gordon and Nelson, 2018; De Greef et al., 2011; Pati et al., 2019; Rachmah et al., 2019; Shriyedeve, Dlungwane, and Tlou, 2019). For example, the mean score of participants who stressed that places for me to exercise are too far away were 2.03 (Davila, 2010). Gordon and Nelson highlighted also that physical activity level was considerably associated with two specific barriers; places for exercising being too far away and perception of exercise as tiring.

Domain 3- Lack of Resource: this domain is related to limited resources including high cost.

Lack of resources were emphasised by participants with especially lower income in some studies (Alzahrani et al., 2019; Algrafri et al., 2017). 30.5% of participants stated that they have got enough and suitable staff to exercise (Algrafri et al., 2017).

Domain 4- Lack of time: This domain emphasis the effect of perceived spent time on PA.

Participants in the six studies emphasised that exercise takes too much of my time (Algrafri et al., 2017; Alzahrani et al., 2019; Anjana et al., 2015; Davila, 2010; Erickson, 2013; Gordon and Nelson, 2018; Kadariyi and Aro, 2018; Oftedal, Bru, and Karlsel, 2011). Erickson (2013), Davila, (2010), and Kadariye and Aro (2018) found that figures the expression for ''exercise takes too much time'' were 2.76, 2.35, and 2.42 respectively. 19.6% participants in the study of Gordon and Nelson, (2018) stressed that exercise takes too much time.

Domain 5- Lack of Knowledge: This domain stresses the importance of knowledge about both DM and performing PA.

The lack of knowledge was a barrier to engage in PA (Erickson, 2013; Rachmah et al., 2019). Participants expressed "I think about how participating in physical activity could change how I manage my diabetes" with the highest mean (2.99) (Erickson, 2013).

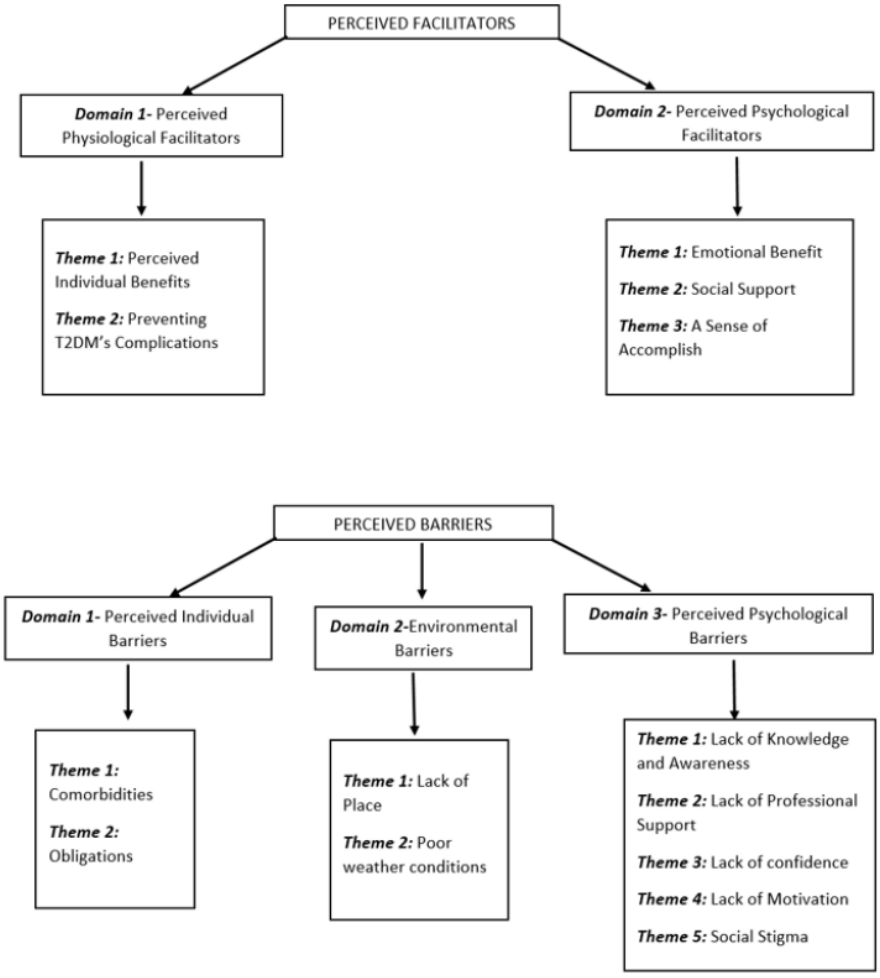
3.4.2 Thematic Synthesis of Qualitative Studies

An inductive thematic analysis was used for synthesis of the perceived barriers and facilitators to PA among people with T2DM. Thematic synthesis reveals a qualitative methodology that is suitable for literature reviews because it presents a qualitative analysis of original qualitative, quantitative, and/or mixed-method studies via the extraction of themes and sub-themes (Fereday and Muir-Cochrane, 2006). After quality assessment is first conducted, themes are developed from the text of selected studies. This evaluation is implemented in an inductive way and is data steered by definition, meaning that the researchers did not seek to make inferences previously established theories or their own ideas, but rather investigate the richness of data as it is offered (Fereday and Muir-Cochrane, 2006).

The results sections of ten qualitative studies and one mix-method study were manually coded by the first author (O.O) in order to create initial codes that turn the data into meaningful themes. These codes were then reviewed to generate themes. Themes were investigated to help explain the objective experiences that cause the subjective dimensions of the barriers and facilitators to PA among persons with T2DM. In this review, 36 codes were produced from qualitative studies and mix-method study, after that nine themes were obtained from codes.

Four domains were created connectional with codes and themes; perceived physiological facilitators, perceived psychological facilitators, perceived physiological barriers, and perceived psychological barriers. The process of attaining themes from studies was shown in **APPENDIX 4.** Themes and domains schematic table in **TABLE 8** were produced.

TABLE 8: Schema of the key themes



3.4.2.1- Perceived Facilitators

Domain 1- Perceived Physiological Facilitator Factors

In this domain two themes relating to participant perceptions of facilitator factors to engage in PA: perceived individual benefits, preventing T2DM's complications.

Theme 1- Perceived Individual Benefits

Perceived benefits of physical activity by people with T2DM within the studies were ranged like that: many participants state that exercising aids them physical fitness and the control of blood glucose (Advika, Idiculla, and Kumari, 2017; Arovah et al., 2019; Casey, Civita, and Dasgupta, 2009; Tulloch et al., 2013). In the one study, better management of hypertension to engage PA was also thought as a motivated factor (Tulloch et al., 2013).

''*I continue my exercise because I have to lose a lot of weight, and I see a lot of results.' AND 'I haven't lost that much pounds up to now, but I have found that continuing the exercising I feel lighter and more fit. I am conditioned now'' (Casey, Civita, and Dasgupta, 2009).*

Theme 2- Preventing T2DM's Complications

Avoiding and postponing T2DM' complications were among the most perceived benefits of engaging PA (Advika, Idiculla, and Kumari, 2017; Arovah et al., 2019; Casey, Civita, and Dasgupta, 2009; Lidegaard et al., 2016; Walker, Valentiner, and Langberg, 2018).

I felt that I had to do something. Diabetes is really awful and the thought of the consequences really scared me (Walker et al., 2018).

"I feel healthier and I also feel my sugar is under control when I exercise." (Advika, Idiculla, and Kumari, 2017).

Domain 2- Perceived Psychological Facilitator Factors

Three themes emerged in relation to perceived psychological facilitator factors: emotional benefit, social support, and a sense of accomplishment.

Theme 1- Emotional Benefit

Engaging in PA was a method to obtain energy and reduce the stress level in daily life (Advika, Idiculla, and Kumari, 2017; Lidegaard et al., 2016; Tulloch et al., 2013).

"I feel active if I go for a walk in the morning." (Advika, Idiculla, and Kumari, 2017).

Theme 2- Social Support

A significant facilitating factors is the collective beliefs of the family members, neighbour and support given the people with T2DM to enable them to exercise regularly (Advika, Idiculla, and Kumari, 2017; Park et al., 2020; Peel et al., 2010; Tulloch et al., 2013).

"As a 54-year-old man, I try to do as much exercise as I can. I play with my children, grandchildren, and just get out on a daily basis and move around as much as I can." (Park et al., 2020).

The sense that PA with others caused interaction and social activity among members was stressed as a really positive and valuable benefit (Arovah et al., 2019; Lidegaard et al., 2016; Park et al., 2020).

"When for some reason I miss my walking routine, let's say for 1 or 2 days, many people will ask me: 'where have you been?' in a way that makes me happy because it means that many people care for me." (Arovah et al., 2019).

Peel et al., (2010) noticed that having a dog, which is thought as an important social support component, also increases the attendance of physical activity.

''Oh yes, I mean that's exercised every day, every morning and the wife usually comes as well so we both get our exercise walking the dog.'' (Peel et al., 2010).

The support of personal trainers were another factor increasing the routine adoption of PA among people living T2DM (Avika, Idiculla, and Kumari, 2017; Casey, Civita, and Dasgupta, 2009; Lidegaard et al., 2016; Park et al., 2020; Tulloch et al., 2013). Attending PA programs were also defined as a supporting factor because these programs presented a regular exercise routine to people with T2DM (Arovah et al., 2019; Casey, Civita, and Dasgupta, 2009; Lidegaard et al., 2016; Walker et al., 2018).

'I think it's just rewarding to have somebody follow me and teach me things that I didn't know, and I worked around my work schedule so that I would be there because I know that there are people that are taking their time to show us things, they are willing to do it, and it was beneficial to me.'' (Casey, Civita, and Dasgupta, 2009).

Theme 3- A Sense of Accomplish

A sense of accomplishment was another psychological facilitator factor of physical activity, mostly among regular walkers, who demonstrated that they felt a sense of accomplishment when they arrived their self-created walking target such as distance, time, walking steps (Arovah et al., 2019; Lidegaard et al., 2016).

"It's really good to use because you can pace yourself by saying that today I'm going to walk 5–6 km, and then you can see when you've actually done it, right. And be satisfied with yourself. For me that's really, really important.' (age 66, diabetes for 7 years, ≥ 30 min daily exercise)" (Lidegaard et al., 2016).

The participants for informants without past experience of structured physical activity evaluated that gaining knowledge and practical experience increased their motivations in the application (Walker et al., 2018).

"It is very much the awareness of your own capability of making a difference … You are in charge of what you can do and you have proof that you really can do something." (Walker et al., 2018).

3.4.2.2 Perceived Barriers

Domain 1- Perceived Individual Barriers

This domain explains the perceived physiological barriers to being PA. The domain consists of two themes: comorbidities and obligations.

Theme 1- Comorbidities

Having many comorbidities such as heart problems, arthritis, colds, muscle soreness, previous major operations was defined by most of the participants as a barrier to being physically active (Avika, Idiculla, and Kumari, 2017; Arovah et al., 2019; Booth et al., 2013; Casey, Civita, and Dasgupta, 2009; Lidegaard et al., 2016; Medagam and Galgauwa, 2018; Peel et al., 2010; Sophia et al., 2018; Tulloch et al., 2013).

"I actually would like to do more exercise; however, sometimes it is often just too painful for me, as doctors told me that I have osteoarthritis and gout in my knees." (Arovah et al., 2019).

"I was very active and did lots of exercises, push-ups, running before having lung cancer. After I had surgery, I can only do a few sit-ups and walking." (Sophia et al., 2018).

Theme 2- Obligations

Many inactive diabetic people reported that constraint for time due to work schedule and other responsibilities such as taking care of children or other family members, home maintenance, or spending time their spouse were important barriers to being physically active into their daily life (Advika, Idiculla, and Kumari, 2017; Arovah et al., 2019; Casey, Civita, and Dasgupta, 2009; Lidergaard et al., 2016; Medagama and Galgauwa, 2018; Miller et al., 2010; Sophia et al., 2018; Tulloch et al., 2013; Walker et al., 2018). Active participants in Arovah et al.'s study reported that their scheduled exercise period sometimes fails due to social responsibilities such as joining communal gatherings.

"It had to be work with me definitely…I think the last one was 6 to 7 or 5 to 6. 'AND' I have my own business also and sometimes I could not go because I'm busy. I have to prepare.' AND 'I worked the whole day...I was just really tired I could not make it, and I could not work on Saturday because they had different times." (Casey, Civita, and Dasgupta, 2009).

"I often do not have enough time to do exercise; in fact, I even decided to retire from my work to care for my elderly mother who needs my support almost constantly." (Arovah et al., 2019).

Domain 2- Environmental Barriers

This domain presents the perceptions of participants on being to be physically active resulting from poor environmental conditions: lack of place and poor weather conditions.

Theme 1- Lack of Place

The lack of infrastructure such as recreational centres, park, gyms, or walkways was defined as an important physical barrier in some studies (Advika, Idiculla, and Kumari, 2017; Arovah et al., 2019; Booth et al., 2013; Casey, Civita, and Dasgupta, 2009; Park et al., 2020), and poor transportation options to reach these centres were another barrier to being physically active (Advika, Idiculla, and Kumari, 2017; Arovah et al., 2019; Booth et al., 2013; Park et al., 2020).

"It would be great to spend some time looking at greenery, maybe in a park or somewhere. It would be a motivation to exercise. Now I go for walk on the main road and traffic poses a problem and this stresses me out and worries my children." (Advika, Idiculla, and Kumari, 2017).

Theme 2- Poor Weather Conditions

Some participants said that poor weather condition negatively affected their willingness to attending or keeping PA (Arovah et al., 2019; Booth et al., 2013; Casey, Civita, and Dasgupta, 2009; Tulloch et al., 2013).

''At different times of the year, weather isn't great so I figure 'oh aye' if I do my exercise but get pneumonia on the way getting me exercise or slip on the ice which again wouldn't do me any favours…I'm a bit reluctant especially in wet weather and icy weather… there's that many dips in footpaths now.'' (Booth et al., 2013).

Domain 3- Perceived Psychological Barriers

This domain is related to perceived psychological barriers being physically active among T2DM individuals. This domain comprises five themes: lack of knowledge and individual awareness, lack of professional support, lack of confidence, lack of motivation, and social stigma.

Theme 1- Lack of knowledge and individual awareness

The positive effects of PA on the control of blood glucose were not known by most participants (Advika, Idiculla, and Kumari, 2017; Arovah et al., 2019; Casey, Civita, and Dasgupta, 2009; Peel et al., 2010).

"They say light exercise is good for you, but I don't know if it helps with the diabetes or not" (Peel et al., 2010).

A minority of people did not perceive obesity as a health issue because obesity is a family history for them. Therefore, they thought that physical activity even to reduce weight was not necessary for them (Advika, Idiculla, and Kumari, 2017).

"Everyone in my family is well built as I am. It is not like I gained weight in the middle I have always been on the heavier side from when I was young." (Advika, Idiculla, and Kumari, 2017).

Theme 2- Lack of Professional Support

Lack of professional support or professional guidelines were significant barriers, many health professionals did not consider the importance of PA and they did not mostly advice about the amount and type of PA in order to perform in people with T2DM in daily life (Advika, Idiculla, and Kumari, 2017; Arovah et al., 2019; Lidergaard et al., 2016; Peel et al., 2010; Sophia et al., 2018).

''I might get rid of my diabetes if I exercised... But actually I really don't know what I should do.'' (Lidegaard et al., 2016).

''They don't ask you anything. They just say "are you getting exercise?" I says "Oh yes I get exercise". They don't enquire as to what type of exercise.'' (Peel et al., 2010).

A poor communication environment that healthcare providers are more dominant than patients during diabetes consultation was seen as lack of professional support by some participants (Miller et al., 2010; Peel et al., 2010).

"I think the exchange between the patient and provider was one-sided with the doctor being impersonal and giving dos and don'ts and the patient didn't seem to take any part in his treatment or exchange of ideas of information which is important."

Theme 3- Lack of Confidence

The lack of knowledge and professional support caused many times a lack of confidence, participants highlighted that the lack of confidence about knowing the participant' performance limit and thought that excessively exercise could damage them, which believed them insecure about an appropriate level of physical activity (Arovah et al., 2019; Lidegaar et al., 2016; Miller et al., 2010; Walker et al., 2018).

''It is very much the awareness of your own capability of making a difference … You are in charge of what you can do and you have proof that you really can do something.'' (Walker et al., 2018).

Theme 4- Lack of Motivation

The measurable and progress changes in the level of blood glucose, fitness level, or weight loss were very important to maintenance to PA (Walker et al., 2018). However, many participants stopped PA due to not seeing immediate results from the applying of PA like that these positive results (Arovah et al., 2019; Miller et al., 2010; Sophia et al., 2018; Walker et al., 2018).

"*I played basketball every day. And when I do that I never lose weight. So it's all a turn off to me." (Miller et al., 2010).*

In the study of Casey, Civita, and Dasgupta (2009), it was remarked that it was difficult to continue regular exercise in the absence of supervision after a physical activity program.

''I needed them… they sat there and they watched, and they went and they checked you and they motivated me…' AND 'She was so nice, and she said, ''let's go, let's go you can'', because I never did exercise before and I thought I would never do it, and she always pushed me to doing it.'' (Casey, Cicita, and Dasgupta, 2009).

Theme 5- Social Stigma

Mostly ignored and an interesting believed being barrier to regular PA was the social stigma, some participants, especially females and people with disability felt uncomfortable or rather felt a judged atmosphere by those around them when they did exercise in public (Advika, Idiculla, and Kumari, 2017; Medagam and Galgauwa, 2018; Park et al., 2020).

"At *my relatives' place, people look upon me weirdly when I go on walks so I avoid exercising when I go out of station." (Advika, Idiculla, and Kumari, 2017).*

4-Discussion:

4.1 Main findings

The present study is the first systematic review with mix-synthesis that analysed the existing quantitative and qualitative literature on the barriers and facilitators to being physically active faced by people with T2DM. Thirty studies were identified: eleven qualitative studies, eighteen quantitative studies, and one mix-method study. The themes attained from narrative and thematic synthesis were combined in the discussion and compared with literature. The evidence demonstrates that there is a need to stress the barriers and facilitators of being physically active for people with T2DM such as socio-demographic factors (diabetes duration, BMI status, income level, education level), self-efficacy, social support, perceived individual benefits and barriers, environmental barriers, and obligations.

4.1.1 Socio-demographic factors:

In this systematic review, socio-demographic factors include; age, gender, diabetes duration, BMI, education level, employment/income status and marital status. These are defined as both facilitators and barriers.

Age factor

Many studies included in this review defined that old age is a hiding factor to being physically active among people with T2DM (Alzahrani et al., 2019; Davila, 2010; Gizaw et al., 2017; Gordon and Nelson, 2018; Koponen, Simonsen, and Suominen 2016; Pati et al., 2018; Shriyedeve, Dlungwane, and Tlou, 2019). However, in the study of Anjana et al., (2015) included in this review found that diabetic elderly people were more active since they had more spare time in order to exercise due to having retired. Although many studies in the literature did not specifically investigate the level of PA of diabetic older people, it is known that 20% of older people have DM and 20% of them are undiagnosed, and 30% of old people have impaired glucose regulation (Crandel, 2014; Sinclair et al., 2012; Kirkman et al., 2012). Thus, the results of PA level of old people can significantly give cue about the level of PA of diabetic old people. The English Longitudinal Study of Ageing evaluated 5000 old people every two years over through

ten years. It was indicated that there is a gradual rise in the proportion of inactive older people (from 5% to 11%), and a gradual decrease in the number of people reporting regular vigorous physical activity (from 35 to 26%) (Smith et al., 2015). Nicklett et al., (2020) and Clarke et al., (2017) found that older people who have been diagnosed with T2DM were associated with lower PA (β: −0.10, 95% CI: −0.13, −0.07). ***Hypothesis 1*:** There is a significant association between aging and low PA. Therefore, Practices and policies that increase the indoor and outdoor physical activities of the elderly should be developed.

Gender

Studies in this review supported that females tend to live more sedentary lives than men (Davila, 2010; Erikson, 2013; Gordon and Nelson, 2018; Kadariye et al., 2018; Pati et al., 2018) except for the study of Shriyedeve, Dlungwane, and Tlou, 2019 and Thu et al., 2016). Recent studies and previous studies in different countries supported that females live more inactive lives than men (Nicklett et al., 2020; Medagama and Galgomuwa, 2018; Ramadhan et al., 2020; Jarvie et al., 2019; Clarke et al., 2017). The systematic review of Mabry et al., (2010) reported similar results with these studies, being physically active for at least 150 minutes per week ranged from 39.0% to 42.1% for men and 26.3% to 28.4% for females. However, Morroto et al., (2007) did not stress a significant correlation to being PA among sexes. Many evidence supports that females live more sedentary lives than men, it should also consider the properties of socio-cultural communities and the source of support in couples. Advika, Idiculla, and Kumari, (2017), Medagam and Galgauwa, (2018), and Park et al., (2020) by stressing social stigma stated that especially women and people with disability felt uncomfortable or rather felt a judgmental atmosphere by those around them when they did exercise in public. In the study conducted in Sri Lanka, all the females felt they were ashamed and uncomfortable to exercise in public places (Medagam and Galgauwa, 2018). Sattler et al., (2018) found that women go through more stigma experiences than men during exercise. Song et al., (2012) reported that males see their female spouses as main sources of social support. In contrast, females assessed non-spouse sources as their main foundations for support.

Diabetes duration

People who had been diagnosed with T2DM 2 years or more had lower PA levels than those who had been diagnosed 6 months and less than (Kadariye et al., 2018; Pati et al., 2018). Nicklett et al., (2020) shown similar results, for example, they found that the level of PA at diagnosis with T2DM demonstrated a small but important increase (β: 0.54, 95% CI: 0.10, 0.97), however, PA continued to decrease slightly after diagnosis at a similar rate as before diagnosis (β: -0.12, 95% CI: -0.32, 0.09). Many studies support that longer diabetes duration was associated with low PA level (Ramadan et al., 2020; Nicklett et al., 2020; Alramadan et al., 2018; Clarke et al., 2017).

BMI status

Shriyedeve, Dlungwane, and Tlou, (2019) and Davila, (2010) did not reflect any important association between PA level and BMI ($p > 0.05$). On the other hand, there were associations between high BMI and low PA level (Anjana et al., 2015; Gizaw et al., 2017; Greef et al., 2011; Pati et al., 2018). These findings were supported by the results of Bught et al., (2019). As such, they found that 74% of subjects were inactive or in low PA, and 65.1% were overweight or obese. Clarke et al., (2020); Morrato et al., (2007) reported that there was a strong relationship between low PA level and high BMI.

Pati et al., (2018) also evaluated perceived weight by diabetic individuals after subjects were weighed. Of the total 321 subjects, a whole mismatch of individual actual and perceived weights was seen. Although 136 subjects were normal weight, 206 subjects perceived themselves as being normal. Similar perceptions were seen for underweight subjects (4 versus 34), and for the overweight and obese categories (72 versus 136 and 9 versus 45). These results are very interesting because a lot of evidence in literature and the results of many studies in this review support that people with high BMI tend to engage in less PA. However, obese or overweight subjects did not see themselves as overweight or obese in the study of Pati and colleagues. Furthermore, although PA was considerably associated with BMI ($p <0.05$), PA self-efficacy among people with T2DM was not related to BMI (Rachmah et al., 2019). They found that participants with a normal BMI were less confident in their capability to engage in PA, with a

lower self-efficacy score (55.7± 28.1) than those with obese/overweight (60.6± 25.9) (Rachmah et al., 2019).

Thus, two hypotheses could be made due to the big differences between actual and perceived-weight. ***Hypothesis 2:*** It is expected that obese people engage in less PA but PA level can increase with the help of mismatch weight perception with the perception of mismatch weight can be transformed into perceived benefits. In contrast, ***Hypothesis 3:*** mismatch weight perception could cause low perceived susceptibility so it is expected that people with low perceived susceptibility engage in less PA. People with low perceived susceptibility might reject that they are at risk for contracting a certain disease (Champion and Skinner, 2008). Hence, future studies should consider actual weight and perceived weight while examining the association between high BMI and low PA.

Income level/employment

While the two studies in this review did not set up an association between PA level and employment, and the level of income (Alzahrani et al., 2019; Shriyedeve, Dlungwane, and Tlou, 2019). People with T2DM who have a job and high income level, performed more PA those of than low income and unemployment (Anjana et al., 2015; Davila, 2010; Gizaw et al., 2017; Gordon and Nelson, 2018; Rachmah et al., 2019). Koetsenruijter and colleges (2015) in the study comprised 1,692 diabetic participants from six Europe countries reported that less PA was related to lower income (OR= 0.75), but, attending community organisations affected positively PA only for people with a low income.

Many studies in literature also supported similar results that people with T2DM in lower socioeconomic positions are more likely to maintain inactive, to move from medium levels of PA to low levels, and to move from high levels of PA to low levels of PA. Those in higher socioeconomic positions are more likely to sustain high levels of PA (Rammadhan et al., 2020, Alramdahan et al., 2018; Chang et al., 2018; Clarke et al., 2017; Thiel et al., 2017; Morroto et al., 2007).However, Direito et al., (2019) reported that the incidence of inadequate PA is projected to be twice as high in high-income countries compared with low-income countries (36.8% vs 16.2%), which is significant considered the fast migration from low to middle/high income economies and consistent urbanisation and rise in sedentary jobs, causing to possible decrease

in PA. ***Hypothesis 4:*** there is a significant association between low PA level and low income, however, community organisation or PA programs can significantly increase PA level for people with low income.

Education level

High education level had a positive factor on increased PA level in the studies (Anjana et al., 2015; Erickson, 2013; Kadariye et al., 2018; Pati et al., 2018), however, the other studies did not see any relationship between increased PA level and high education level (Gizaw et al., 2017; Gordon and Nelson, 2018; Shriyedeve, Dlungwane, and Tlou, 2019). Nicklett et al., (2020) demonstrated in their study with 2,394 participants in the USA that higher levels of education was associated with high level PA, with those graduated university or more having 2.36 higher MET scores than those with less than a high school education (95% CI: 1.34, 3.37). However, Morroto et al., (2007) did not find any association between high PA level and education level in their survey with 23,283 participants in the USA. There is a need the future studies to measure the association between education level and PA in people with T2DM.

Marital Status

Alzahrani et al., (2019) and Shriyedeve, Dlungwane, and Tlou, (2019) were not set up an association between marital status and PA level.

4.1.2 Self-efficacy:

Self-efficacy is defined as the belief a person has in his/her abilities, specifically their ability to overcome the challenges ahead of them and complete a task successfully (e.g., parenting, sports, academic, diet, exercise) (Akhtar, 2008).

Adeniye et al., (2012); Davila, (2010); Gizaw et al., (2017); Sweet et al., (2009); Thu et al., (2016) highlighted the importance of self-efficacy on PA among people with T2DM. The lower the PA self-efficacy belief was associated with the lower the PA level, and also the higher the PA self-efficacy belief was associated with the higher the PA self-efficacy beliefs. Racmah et al., (2019) found that self-efficacy of participants to overcome barriers to engage in PA (52.5± 13.8) was lower than their self-efficacy to engage in PA (59.1±26.4). Self-efficacy also had an important role on the PA level of the participants (p=0.001). Dutton et al., (2009) and Olson and McAuley,

(2015) indicated that the treatment effect on PA was completely mediated by changes in self-efficacy among people with T2DM.

While self-efficacy depends on a person's belief in their own ability to success, motivation relies on the person's wish to success, however, a person advances or maintains self-efficacy via the experience of achievement, the person mostly get an increase in motivation in order to continue making and learning progress (Schunk and DiBenedetto, 2020). A sense of accomplishment and gaining knowledge and practical experience were motivation factors in the starting to PA for participants evaluated in this review (Arovah et al., 2019; Lidegaard et al., 2016; Walker et al., 2018). Nonetheless, not seeing in a short-time outcomes resulting from the applying of PA such as the level of blood glucose, fitness level, or weight loss leaded the lack of motivation, and the participants did not maintain to engaging in PA (Arovah et al., 2019; Miller et al., 2010; Sophia et al., 2018; Walker et al., 2018). Previous studies have recommended that perceived abilities or self-efficacy cognitions have a significant role in both the adoption and the maintenance of exercise behaviours (Kaplan et al., 1984; McAuley and Jacobson, 1991; Sallis et al., 1986). The participants evaluated in this review stressed that the lack of confidence about knowing themselves' performance limit and thought that excessively exercise could damage them, which believed them insecure about an appropriate level of PA (Arovah et al., 2019; Lidegaar et al., 2016; Miller et al., 2010; Walker et al., 2018).

4.1.3 Social Support:

Family Support

Social environment was identified as a supportive factor in the many studies (Advika, Idiculla, and Kumari, 2017; Arovah et al., 2019; Kadariye and Aro, 2018; Lidegaard et al., 2016; Pati et al., 2018; Park et al., 2020; Peel et al., 2010; Shriyedeve, Dlungwane, and Tlou, 2019; Tulloch et al., 2013). Previous many studies supported that family or friends were supportive environment for PA (King et al., 2010; Ramkisson, Pillay, and Sibanda, 2017; Ramadhan et al., 2019; Roslan et al., 2008; Shaw et al., 2006; Wen, Shepherd, and Pachman, 2004). Having a spouse was related to a better physical health status (B= 1.01), particularly for people with a high income (Koetsenruijter et al., 2015). Zhou, Grady, and Chen, (2017) reported that the social networks of

neighbours aided to start, regulate, and maintain PA. However, social environment in some studies was either ineffective or discouraging factor (Algrafri et al., 2017; Alzahrani et al., 2019; Gordon and Nelson, 2018; Kadariye and Aro, 2018; Eickson, 2013; Adeniyi et al., 2012; Dyck et al., 2011). Gleeson-Kreig, (2008) found that the common idea of social support, that from friends and family was scored fairly low.

Support of Health professionals

Social or professional support from health professionals was also a factor that increases the level of PA among T2DMs (Avika, Idiculla, and Kumari, 2017; Casey, Civita, and Dasgupta, 2009; Gizaw et al., 2017; Gordon and Nelson, 2018; Kadariye and Aro, 2018; Lidegaard et al., 2016; Park et al., 2020; Tulloch et al., 2013 Pati et al., 2018; Shopia et al., 2018). Many studies in the literature remarked the importance of statement of exercise by health professionals in increase of PA (Arena et al., 2018; Fletcher et al., 1996; Fletcher et al., 1992; Freene et al., 2019; Sørensen, Skovgaard and Puggaard, 2006; Vuori, Lavie, and Blair, 2013).

On the other hand, many studies demonstrated that the doctors and nurses spent little time on PA counselling (Bock, Diehm, and Schneider, 2012; Livaudais et al., 2005; Podl et al., 1999; Poskiparta, Kasila and Kiuru, 2006; Ramadhan et al., 2019; VanWormer, Pronk, and Kroeninger, 2009). For example, 70% of Canadian doctors stated using verbal counselling in order to promote PA, 16% documented using written prescriptions (Smith et al., 2011). 84% of Catalan primary care physicians stated rarely promoting PA (Ribera, McKenna, and Riddoch, 2005). The results of many studies included in this study were consistent with the previous studies in that many participants stated that health professionals did not advice on the kind and amount of PA to practice (Advika, Idiculla, and Kumari, 2017; Arovah et al., 2019; Lidergaard et al., 2016; Miller et al., 2010; Peel et al., 2010; Sophia et al., 2018). Furthermore, many studies remarked the lack of knowledge about the quality and kind of PA due to the absence of health professionals or guidelines (Advika, Idiculla, and Kumari, 2017; Arovah et al., 2019; Casey, Civita, and Dasgupta, 2009; Erickson, 2013; Peel et al., 2010).

Many doctors might transfer the duty of providing protective services to other members of the healthcare team; however, the doctors must not neglect their responsibilities in order to enhance and other health improving strategies (Calfas et al., 1996; Eaker et al., 1999). Nurses

with other health professionals are an integral part of the healthcare team might evaluate prescribed exercise, physical activity habits, monitor responses to exercise in individuals, provide a regular follow-up (Kottke, Solberg, and Brekke, 1990). However, in their systematic review, Franklin et al., (2018) stressed that a traditional didactic method dominates over the progress of collaborative connections in the provision of self-management support. Health professionals depend on the supply of common information related to the lifestyle and condition with the view that knowledge is enough to realise behavioural change (Franklin et al., 2018). On the other hand, Gordon and Nelson, (2018) found that there were no significant differences in the mean scores for knowledge of the benefits of exercise by PA level (65.8% in those who were high active, 66.2 in those moderately active, and 62.2% in those low active. Knowledge about the benefits of PA is an important factor for behaviour change but it cannot be an adequate condition in order to change behaviour alone. 279 (87.5%) of subjects had knowledge about the benefits of PA and diabetes, however, they did not engage in recommended PA practice (Gizaw et al., 2017). ***Hypothesis 5:*** Health professionals could significantly increase PA level for people with T2DM by developing PA prescriptions for per patient rather than only didactic approach. ***Hypothesis 6:*** Health professionals could significantly increase self-efficacy level by giving regular feedback about the improvements of health after PA.

4.1.4 Perceived Individual Benefits and Barriers:

Both active and inactive participants in the studies highlighted the benefits of PA on diabetes such as the improving of glycaemic level, physical fitness, functioning of cardiovascular, body looks, avoiding and postponing T2DM' complications (Advika, Idiculla, and Kumari, 2017; Anjana et al., 2015; Arovah et al., 2019; Casey, Civita, and Dasgupta, 2009; Davila, 2010; Gizaw et al., 2017; Gordon and Nelson, 2018; Kadariye et al., 2018; Koponen, Simonsen, Lidegaard et al., 2016; Suominen 2016; Shriyedeve, Dlungwane, and Tlou, 2019; Tulloch et al., 2013; Walker, Valentiner, and Langberg, 2018).

Active participants felt that PA improves mental health and reduces the stress levels compared to inactive participants (Advika, Idiculla, and Kumari, 2017; Anjana et al., 2015; Davila, 2010; Kadariye and Aro, 2018; Koponen, Simonsen, and Suominen 2016; Lidegaard et al., 2016; Oftedal, Bru, & Karlsen, 2011; Pati *et al.,* 2019; Tulloch *et al.,* 2013). Häkkinen et al., (2009)

found that physically more active people at high risk for T2DM had lower body weight and less depressive symptoms. In the cross-sectional study comprised 1,237194 people aged 18 years or older was reported that persons who engaged in a PA had 1.49 (43.2%) fewer days of mental problems in the past month than person who did not engage in PA the USA (Chekroud et al., 2018). In the result of all evaluations, there is a strong association between low level mental health problems or stress and increased PA. Wallace et al., (2016) defined that active commuters had a variety of facilitator factors differently from physical health these included mental health, financial saving, and interaction with people and the environment.

According to the health belief model, if a person believes that a specific action will decrease susceptibility to a health problem or its complications, the person is probably to engage in that behaviour irrespective of objective facts regarding the effectiveness of the action (Champion and Skinner, 2008). However, in the studies which consisted of 3,502 participants, remarkably more than 60% of participants were inactive (Davila, 2010; Gizaw et al., 2017; Koponen, Simonsen, and Suominen, 2016; Shriyedeve, Dlungwane, and Tlou, 2019). The studies consisted of 785 participants reported that nearly 40% of participants were low physical active (Gordon and Nelson, 2018; Kadriye et al., 2018; Pati et al., 2018). ***Hypothesis 7:*** Perceived barriers predominate than perceived benefits to being PA among people with T2DM.

The perceived individual barriers to being physically active were defined as 'exercise is tiring'', ''exercise is fatiguing'', and ''exercise is hard work'' (Anjana et al., 2015; Davila et al., 2010; Erickson, 2013; Gordon and Nelson, 2018; Pati et al., 2019). Moreover, having many comorbidities such as arthritis, colds, heart problems, previous major operations were defined as individual barriers (Avika, Idiculla, and Kumari, 2017; Arovah et al., 2019; Booth et al., 2013; Casey, Civita, and Dasgupta, 2009; Lidegaard et al., 2016; Peel et al., 2010; Sophia et al., 2018; Tulloch et al., 2013). Thu et al., (2016) found that perceived barriers and perceived benefits could not estimate PA. ***Hypothesis 8:*** Perceived barriers could significantly decrease with social support, professional support, and PA organisations. The future studies could directly observe the effect of professional support and PA organisations role in the increase of PA. However, it is difficult to observe the effect of social support because it comprises many components. However, social support could be increased by making public service with the help of mass media.

4.1.5 Environmental Barriers

The perceived environmental barriers to being physically active among in many samples were the lower availability and quality of walking infrastructure, the lack of safe road and places, places for exercising being too far away, and poor weather conditions (Advika, Idiculla, and Kumari, 2017; Anjan et al., 2015; Arovah et al., 2019; Booth et al., 2013; Casey, Civita, and Dasgupta, 2009; Davila et al., 2010; Gordon and Nelson, 2018; Greef et al., 2011; Park et al., 2020; Pati et al., 2019; Rachmah et al., 2019; Shriyedeve, Dlungwane, and Tlou, 2019; Tulloch et al., 2013). Uddina, Burton and Khan, (2018) in their cross-sectional study among adults in Bangladesh found that the most often reported barriers were lack of neighbourhood safety (OR 4.65 [95% CI 3.09–7.00]), poor street lighting at night (OR 2.8282 [95% CI 1.95–4.11]), lack of convenient places (OR 2.04 [95% CI 1.39–3.00]), unclean and untidy neighbourhood (OR 1.84 [95% CI 1.25–2.72]) and poor weather (OR 1.61 [95% CI 1.11–2.33]). These barriers were especially stated by more women than men (Uddina, Burton and Khan, 2018). Environmental barriers are not only related to diabetic people, they are problems related to all communities. ***Hypothesis 9:*** Environmental barriers could be minimized by municipalities or administrators to increase the level of PA in the community with environmental regulations. ***Hypothesis 10:*** The level of PA of females could significantly be increased with environmental regulations (i) more safe PA places provide more female attendance in PA, (ii) more PA places provide more PA opportunity to more people, and social stigma decreases.

4.1.6 Lack of time

Some obligations such as work schedule, taking care of children or other family members, home maintenance, or spending time with their spouse were defined as significant barriers to being physically active in their daily lives (Advika, Idiculla, and Kumari, 2017; Arovah et al., 2019; Casey, Civita, and Dasgupta, 2009; Lidergaard et al., 2016; Miller et al., 2010; Sophia et al., 2018; Tulloch et al., 2013; Walker et al., 2018). Therefore, the lack of time for PA were emphasised in the many studies (Algrafri et al., 2017; Alzahrani et al., 2019; Anjana et al., 2015; Davila, 2010; Erickson, 2013; Gordon and Nelson, 2018; Kadariyi and Aro, 2018; Oftedal, Bru, and Karlsel, 2011). However, Rebar et al., (2017) constituted clusters which were entirely inactive (29%) or active while doing either leisure (18%), occupation (18%), transport (14%), or household (22%) activities. After, they found no significant differences how much people perceived that lack of

time were a PA barrier. ***Hypothesis 11:*** More PA programs or organisations could provide more attendance to PA because the statement of the lack of time was defined by both active and inactive people.

4.2 Strengths and Limitations of the review

There were various strengths in this review. The protocol of this review was published on Prospero. The findings reflected a variety of population with T2DM across the different countries ranging from Europe to Asia. This study provided a deeper understanding of the factors that are the barriers and facilitators of PA participation among people living with T2DM. This study contributed to determining ideas for the decrease of barrier factors and the increase of facilitator factors to being physically active among people with T2DM. The high MMAT scores increase the reliability of the results of this study. Additionally, the generalisability of quantitative studies was high due to giving answers related to sampling across studies identified in MMAT. However, this review had a number of limitations. It might be subject to language bias because the review only included the studies written in English. The lack of the researcher's epistemological views, particularly in qualitative studies, was a concern for the current evidence base as the investigators have the opportunity to interpret the research outcomes. A further limitation was only four databases were used, not grey literature. Thus, some relevant studies can be missed in the review.

5. Conclusion and recommendations for research and practice

The low PA is a significant factor for low quality of health, the impaired of health and the development of chronic complications in people with T2DM. Many evidence supports that PA level is very low among individuals with T2DM. This review searched the reasons for low PA by examining facilitators and barriers to being physically active for people with T2DM. Overall, the 30 studies meeting the inclusion criteria were evaluated against hematic and narrative synthesis. Drawing from the analysed findings, several recommendations were represented for clinical service, public practice and research to assist the understanding the barriers and facilitators of physical activity participation among people living with type 2 diabetes.

In the result of all evaluations, perceived physiological facilitators (e.g. exercising increases my level of physical fitness, exercising improves functioning of my cardiovascular system) and

perceived psychological benefits (e.g. exercising decreases stress) were defines as facilitators, however, these facilitators were expression or knowledge because many participates stopped exercise the before of these improvements in the body. Therefore, these facilitators were only belief.

The support of health professionals and the sense of accomplishment were also defined as facilitators. These facilitator factors were real factors rather than belief. Because many participants stated that they started or maintained to exercise with advice and following of a health professional. Moreover, when participants arrived their self-created walking target such as distance, time, walking steps, they continued to PA. Thus, the support of health professionals and the sense of accomplishment to engage in PA are very important. Health professionals should arrange prescriptions for patients and they should help their patients in making a self-created walking target. Hospital administrators should try to increase the number of health-staff to spare more time for patients and present more education to their staff about PA plans according to patients' needs. Public health services also should focus on plans and programs to increase PA in the community and among people with T2DM. Future studies could focus on both the role of health professionals and creating targets to increase engaging and maintaining in PA.

On the other hand, perceived barriers were mostly problems facing in daily life rather than belief. Mainly barriers stated by participants were lack of place, lack of income, absence of comorbidities, lack of knowledge, lack of awareness, lack of social support, lack of professional support, lack of resource, obligations, poor weather conditions, lack of self-efficacy, lack of confidence, lack of motivation, lack of social support and social stigma.

Many organisations should give roles to decrease these barriers in being physically active. For example, municipalities could provide places, resources, or infrastructure for exercise. More exercise places increase the attendance of PA in community by rising social interactions and by decreasing social stigma. Moreover, PA organisations with the help of municipalities could increase PA level in people with low-income. The media could also play a significant role on the importance of PA in the increase of awareness in people with inactive and in the social environment. Health professionals could support inactive people on the instructions of PA, and they could help to the decrease of lack of self-efficacy, lack of motivation, lack of confidence

with the help of the individual himself/herself and families. They might arrange the prescriptions of PA according to individuals' comorbidities.

After the arrangements of all physical activity, it is expected that the perceived physiological benefits and the perceived psychological benefits could be transformed from belief into the real health outcome with the help of especially health professionals, municipalities, managers, and the media.

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Appendix 1

PART I. MMAT criteria & one-page template (to be included in appraisal forms)

Types of mixed methods study components or primary studies	Methodological quality criteria (see tutorial for definitions and examples)	Responses: Yes	No	Can't tell	Comments
Screening questions (for all types)	• Are there clear qualitative and quantitative research questions (or objectives*), or a clear mixed methods question (or objective*)?				
	• Do the collected data allow address the research question (objective)? E.g., consider whether the follow-up period is long enough for the outcome to occur (for longitudinal studies or study components).				
	Further appraisal may be not feasible or appropriate when the answer is 'No' or 'Can't tell' to one or both screening questions.				
1. Qualitative	1.1. Are the sources of qualitative data (archives, documents, informants, observations) relevant to address the research question (objective)?				
	1.2. Is the process for analyzing qualitative data relevant to address the research question (objective)?				
	1.3. Is appropriate consideration given to how findings relate to the context, e.g., the setting, in which the data were collected?				
	1.4. Is appropriate consideration given to how findings relate to researchers' influence, e.g., through their interactions with participants?				
2. Quantitative randomized controlled (trials)	2.1. Is there a clear description of the randomization (or an appropriate sequence generation)?				
	2.2. Is there a clear description of the allocation concealment (or blinding when applicable)?				
	2.3. Are there complete outcome data (80% or above)?				
	2.4. Is there low withdrawal/drop-out (below 20%)?				
3. Quantitative non-randomized	3.1. Are participants (organizations) recruited in a way that minimizes selection bias?				
	3.2. Are measurements appropriate (clear origin, or validity known, or standard instrument; and absence of contamination between groups when appropriate) regarding the exposure/intervention and outcomes?				
	3.3. In the groups being compared (exposed vs. non-exposed; with intervention vs. without; cases vs. controls), are the participants comparable, or do researchers take into account (control for) the difference between these groups?				
	3.4. Are there complete outcome data (80% or above), and, when applicable, an acceptable response rate (60% or above), or an acceptable follow-up rate for cohort studies (depending on the duration of follow-up)?				
4. Quantitative descriptive	4.1. Is the sampling strategy relevant to address the quantitative research question (quantitative aspect of the mixed methods question)?				
	4.2. Is the sample representative of the population understudy?				
	4.3. Are measurements appropriate (clear origin, or validity known, or standard instrument)?				
	4.4. Is there an acceptable response rate (60% or above)?				
5. Mixed methods	5.1. Is the mixed methods research design relevant to address the qualitative and quantitative research questions (or objectives), or the qualitative and quantitative aspects of the mixed methods question (or objective)?				
	5.2. Is the integration of qualitative and quantitative data (or results*) relevant to address the research question (objective)?				
	5.3. Is appropriate consideration given to the limitations associated with this integration, e.g., the divergence of qualitative and quantitative data (or results*) in a triangulation design?				
	Criteria for the qualitative component (1.1 to 1.4), and appropriate criteria for the quantitative component (2.1 to 2.4, or 3.1 to 3.4, or 4.1 to 4.4), must be also applied				

*These two items are not considered as double-barreled items since in mixed methods research, (1) there may be research questions (quantitative research) or research objectives (qualitative research), and (2) data may be integrated, and/or qualitative findings and quantitative results can be integrated.

PART II. MMAT tutorial

Types of mixed methods study components or primary studies	Methodological quality criteria
1. Qualitative Common types of qualitative research methodology include: A. Ethnography The aim of the study is to describe and interpret the shared cultural behaviour of a group of individuals. B. Phenomenology The study focuses on the subjective experiences and interpretations of a phenomenon encountered by individuals. C. Narrative The study analyzes life experiences of an individual or a group. D. Grounded theory Generation of theory from data in the process of conducting research (data collection occurs first). E. Case study In-depth exploration and/or explanation of issues intrinsic to a particular case. A case can be anything from a decision-making process, to a person, an organization, or a country. F. Qualitative description There is no specific methodology, but a qualitative data collection and analysis, e.g., in-depth interviews or focus groups, and hybrid thematic analysis (inductive and deductive). Key references: Creswell, 1998; Schwandt, 2001; Sandelowski, 2010.	**1.1. Are the sources of qualitative data (archives, documents, informants, observations) relevant to address the research question (objective)?** E.g., consider whether (a) the selection of the participants is clear, and appropriate to collect relevant and rich data; and (b) reasons why certain potential participants chose not to participate are explained. **1.2. Is the process for analyzing qualitative data relevant to address the research question (objective)?** E.g., consider whether (a) the method of data collection is clear (in depth interviews and/or group interviews, and/or observations and/or documentary sources); (b) the form of the data is clear (tape recording, video material, and/or field notes for instance); (c) changes are explained when methods are altered during the study; and (d) the qualitative data analysis addresses the question. **1.3. Is appropriate consideration given to how findings relate to the context, e.g., the setting, in which the data were collected?** * E.g., consider whether the study context and how findings relate to the context or characteristics of the context are explained (how findings are influenced by or influence the context). "For example, a researcher wishing to observe care in an acute hospital around the clock may not be able to study more than one hospital. (…) Here, it is essential to take care to describe the context and particulars of the case [the hospital] and to flag up for the reader the similarities and differences between the case and other settings of the same type" (Mays & Pope, 1995). The notion of context may be conceived in different ways depending on the approach (methodology) tradition. **1.4. Is appropriate consideration given to how findings relate to researchers' influence, e.g., through their interactions with participants?** * E.g., consider whether (a) researchers critically explain how findings relate to their perspective, role, and interactions with participants (how the research process is influenced by or influences the researcher); (b) researcher's role is influential at all stages (formulation of a research question, data collection, data analysis and interpretation of findings); and (c) researchers explain their reaction to critical events that occurred during the study. The notion of reflexivity may be conceived in different ways depending on the approach (methodology) tradition. E.g., "at a minimum, researchers employing a generic approach [qualitative description] must explicitly identify their disciplinary affiliation, what brought them to the question, and the assumptions they make about the topic of interest" (Caelli, Ray & Mill, 2003, p. 5).

*See suggestion on the MMAT wiki homepage (under '2011 version'): Independent reviewers can establish a common understanding of these two items prior to beginning the critical appraisal.

Types of mixed methods study components or primary studies	Methodological quality criteria
2. Quantitative randomized controlled (trials) Randomized controlled clinical trial: A clinical study in which individual participants are allocated to intervention or control groups by randomization (intervention assigned by researchers). Key references: Higgins & Green, 2008; Porta, 2008; Oxford Center for Evidence based medicine, 2009.	**2.1. Is there a clear description of the randomization (or an appropriate sequence generation)?** In a randomized controlled trial, the allocation of a participant (or a data collection unit, e.g., a school) into the intervention or control group is based solely on chance, and researchers describe how the randomization schedule is generated. "A simple statement such as 'we randomly allocated' or 'using a randomized design' is insufficient". *Simple randomization:* Allocation of participants to groups by chance by following a predetermined plan/sequence. "Usually it is achieved by referring to a published list of random numbers, or to a list of random assignments generated by a computer". *Sequence generation:* "The rule for allocating interventions to participants must be specified, based on some chance (random) process". Researchers provide sufficient detail to allow a readers' appraisal of whether it produces comparable groups. E.g., blocked randomization (to ensure particular allocation ratios to the intervention groups), or stratified randomization (randomization performed separately within strata), or minimization (to make small groups closely similar with respect to several characteristics).
	2.2. Is there a clear description of the allocation concealment (or blinding when applicable)? *The allocation concealment protects assignment sequence until allocation.* E.g., researchers and participants are unaware of the assignment sequence up to the point of allocation. E.g., group assignment is concealed in opaque envelops until allocation. *The blinding protects assignment sequence after allocation.* E.g., researchers and/or participants are unaware of the group a participant is allocated to during the course of the study.
	2.3. Are there complete outcome data (80% or above)? E.g., almost all the participants contributed to almost all measures.
	2.4. Is there low withdrawal/drop-out (below 20%)? E.g., almost all the participants completed the study.

APPENDIX 2 : JBI Templates

JBI QARI Data Extraction Form for Interpretive and Critical Research

Reviewer _____ Date _____
Author _____ Year _____
Journal _____ Record number _____

Study description

Methodology _____

Method _____

Intervention _____

Setting _____

Geographical _____

Cultural _____

Participants _____

Data analysis _____

Authors' conclusions

_____

_____

Comments

_____

_____

Findings	Illustration from publication (page number)	Evidence		
		Unequivocal	Credible	Unsupported

Extraction of findings complete YES/NO

JBI Data Extraction Form for Experimental/Observational Studies

Reviewer _____ Date _____
Author _____ Year _____
Journal _____ Record number _____

Study method RCT Quasi-RCT Longitudinal
Retrospective Observational Other _____

Participants
Setting _____
Population _____

Sample size
Intervention 1 _____ Intervention 2 _____ Intervention 3 _____

Interventions
Intervention 1 _____
_____

Intervention 2 _____
_____

_____

Clinical outcome measures

Outcome description	Scale/measure

Study results

(a) Dichotomous data

Outcome	Intervention ( ) number/total number	Intervention ( ) number/total number

(b) Continuous data

Outcome	Intervention ( ) mean & SD (number)	Intervention ( ) mean & SD (number)

Authors' conclusions

_____

_____

Comments

_____

_____

APPENDIX 3: The results of MMAT's evaluations

Qualitative Studies

Advika, Idiculla, Kumari, 2017
(Interview)

Questions	Yes	No	Can't tell	Comments	Quality score
1.1	✓			Clear the selection of the participants	¾
1.2	✓			Clear the method of data collection	75%
1.3	✓			Explanation how finding relate to context.	
1.4		✓		No explanation how findings relate to their findings	

Arovah, Kushartanti, Washigton, Heesch, 2019
(Focus group)

Questions	Yes	No	Can't tell	Comments	Quality score
1.1	✓			Clear the selection of the participants	¾
1.2	✓			Clear the method of data collection	75%
1.3	✓			Explanation how finding relate to context.	
1.4		✓		No explanation on researcher's influence in study.	

Booth et al., 2013
(Focus group)

Questions	Yes	No	Can't tell	Comments	Quality score
1.1	✓			Clear the selection of the participants	¾
1.2	✓			Clear the method of data collection	75%
1.3	✓			Explanation how finding relate to context.	
1.4		✓		No explanation on researcher's influence in study.	

Casey, Civita, & Dasgupta, 2010
(Focus group)

Questions	Yes	No	Can't tell	Comments	Quality score
1.1	✓			Clear the selection of the participants	¾
1.2	✓			Clear the method of data collection	75%
1.3	✓			Explanation how finding relate to context.	
1.4		✓		No explanation on researcher's influence in study.	

Lidegaard, Schwennesen, Willaing and Færch, 2016
(Focus group)

Questions	Yes	No	Can't tell	Comments	Quality score
1.1	✓			Clear the selection of the participants	¾
1.2	✓			Clear the method of data collection	75%
1.3	✓			Explanation how finding relate to context.	
1.4		✓		No explanation on researcher's influence in study.	

Medagama & Galgomuwa, 2018
(Interviews)

Questions	Yes	No	Can't tell	Comments	Quality score
1.1	✓			Clear the selection of the participants	¾
1.2	✓			Clear the method of data collection	75%
1.3	✓			Explanation how finding relate to context.	
1.4		✓		No explanation on researcher's influence in study.	

Miller, Marolen, & Beech, 2010
(Moderator-led focus group)

Questions	Yes	No	Can't tell	Comments	Quality score
1.1		✓		Unclear the selection of the participants.	½
1.2	✓			Clear the method of data collection	50%
1.3	✓			Explanation how finding relate to context.	
1.4		✓		No explanation on researcher's influence in study.	

Park et al., 2020
(An emergent)

Questions	Yes	No	Can't tell	Comments	Quality score
1.1		✓		Unclear the selection of the participants.	¾
1.2	✓			Clear the method of data collection	75%
1.3	✓			Explanation how finding relate to context.	
1.4	✓			Explanation on researcher's influence in study.	

Peel, Douglas, Parry, & Lawton, 2010 *(Longitudinal, repeat in-depth interview)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
1.1	✓			Clear the selection of the participants	¾
1.2	✓			Clear the method of data collection	75%
1.3	✓			Explanation how finding relate to context.	
1.4		✓		No explanation on researcher's influence in study.	

Tulloch et al., 2013 *(Interview)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
1.1	✓			Clear the selection of the participants	
1.2	✓			Clear the method of data collection	100%
1.3	✓			Explanation how finding relate to context.	
1.4	✓			Explanation on researcher's influence in study.	

Walker, Valentiner, & Langberg, 2018 *(Semi-structured, individual, interview)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
1.1		✓		Unclear the selection of the participants.	
1.2	✓			Clear the method of data collection	25%
1.3		✓		No explanation how finding relate to context.	
1.4		✓		Explanation on researcher's influence in study.	

Quantitative Randomised Controlled Trail (RCTs) Studies

Dyck et al., 2011 *(RCTs)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
2.1	✓			There is a clear explanation of randomisation.	¾
2.2		✓		Blinding to group allocation could not be maintained post-recruitment.	75%
2.3	✓			All the participants contributed to almost all measures	
2.4	✓			All the participants completed the study	

Sweet et al., 2009 *(RCTs)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
2.1		✓		There is no a clear explanation of randomisation.	¼
2.2		✓		Blinding to group allocation could not be maintained post-recruitment.	25%
2.3	✓			All the participants contributed to almost all measures.	
2.4		✓		26.5 of the participants did not complete the study	

Quantitative-Non-Randomised Control Studies)

Adeniyi, Idowu, Ogwumike, Adeniyi, 2012 *(Cross- sectional)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
3.1	✓			The sample is representative of the population.	¾ 75%
3.2	✓			The measurements are conducted with standard instruments.	
3.3		✓		There is no a clear explanation about dissimilation about groups.	
3.4	✓			There is a 80% over complete data outcome.	

Alghafri et al., (2017) *(Cross- sectional interview-based)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
3.1	✓			The sample is representative of the population.	¾ 75%
3.2	✓			The measurements are conducted with standard instruments.	
3.3		✓		There is no a clear explanation about dissimilation about groups.	
3.4	✓			There is a 80% over complete data outcome.	

Alzahrani et al., 2019 *(Cross- sectional)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
3.1	✓			The sample is representative of the population.	100%
3.2	✓			The measurements are conducted with standard instruments.	
3.3	✓			There is no a clear explanation about dissimilation about groups.	
3.4	✓			There is a 80% over complete data outcome.	

Anjana et al., 2015 *(Cross-sectional)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
3.1	✓			The sample is representative of the population.	100%
3.2	✓			The measurements are conducted with standard instruments.	
3.3	✓			There is a clear explanation of dissimilation about groups.	
3.4	✓			There is a 80% over complete data outcome.	

Gizaw, Ababulgu, Gebrestsadik, & Abraha, 2019 *(A facility-based cross-sectional)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
3.1	✓			The sample is representative of the population.	100%
3.2	✓			The measurements are conducted with standard instruments.	
3.3	✓			There is a clear explanation of dissimilation about groups.	
3.4	✓			There is a 80% over complete data outcome.	

Gordon & Nelson, 2018 *(Cross-sectional)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
3.1	✓			The sample is representative of the population.	100%
3.2	✓			The measurements are conducted with standard instruments.	
3.3	✓			There is a clear explanation of dissimilation about groups.	
3.4	✓			There is a 80% over complete data outcome.	

Greef et al., 2011 *(Cross- sectional)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
3.1	✓			The sample is representative of the population.	100%
3.2	✓			The measurements are conducted with standard instruments.	
3.3	✓			There is a clear explanation of dissimilation about groups.	
3.4	✓			There is 80% over complete data outcome.	

Oftedal, Bru, & Karlsen, 2011 *(Cross- sectional)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
3.1	✓			The sample is representative of the population.	100%
3.2	✓			The measurements are conducted with standard instruments.	
3.3	✓			There is a clear explanation of dissimilation about groups.	
3.4	✓			There is a 80% over complete data outcome.	

Pati et al., 2019 *(Cross-sectional, facility-based study)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
3.1	✓			The sample is representative of the population.	100%
3.2	✓			The population is a representative sample.	
3.3	✓			There is a clear explanation of dissimilation about groups.	
3.4	✓			There is a 80% over complete data outcome.	

Thu et al., 2016 (cross-sectional, analytic study)					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
3.1	✓			The sample is representative of the population.	¾ 75%
3.2	✓			The population is a representative sample.	
3.3		✓		There is a clear explanation of dissimilation about groups.	
3.4	✓			There is a 80% over complete data outcome.	

Quantitative-descriptive studies

Dávila, 2010 *(Non-experimental, a descriptive correlational study)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
4.1	✓			The sample size is justified.	100%
4.2	✓			The population is a representative sample.	
4.3	✓			The measurements are conducted with standard instruments.	
4.4	✓			There is a 60% over complete data outcome.	

Erickson, 2013 *(A descriptive cross-sectional)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
4.1	✓			The sample size is justified.	100%
4.2	✓			The population is a representative sample.	
4.3	✓			The measurements are conducted with standard instruments.	
4.4	✓			There is a 60% over complete data outcome.	

Kadariye et al., 2018
(A descriptive Cross-sectional)

Questions	Yes	No	Can't tell	Comments	Quality score
4.1	✓			The sample size is justified.	100%
4.2	✓			The population is a representative sample.	
4.3	✓			The measurements are conducted with standard instruments.	
4.4	✓			There is a 60% over complete data outcome.	

Koponen et al., 2017
(Survey)

Questions	Yes	No	Can't tell	Comments	Quality score
4.1	✓			The sample size is justified.	100%
4.2	✓			The population is a representative sample.	
4.3	✓			The measurements are conducted with standard instruments.	
4.4	✓			There is a 60% over complete data outcome.	

Rachmah et al., 2019
(A descriptive analytic cross-sectional study)

Questions	Yes	No	Can't tell	Comments	Quality score
4.1	✓			The sample size is justified.	100%
4.2	✓			There is not a clear explanation of eligible criteria.	
4.3	✓			The measurements are conducted with standard instruments.	
4.4	✓			There is a 60% over complete data outcome.	

Shiriyedeve, Dlungwane, & Tlou, 2019
(An observational cross-sectional)

Questions	Yes	No	Can't tell	Comments	Quality score
4.1	✓			The sample size is justified.	¾
4.2		✓		There is not a clear explanation of eligible criteria.	75%
4.3	✓			The measurements are conducted with standard instruments.	
4.4	✓			There is a 60% over complete data outcome.	

Mixed-Method Studies

Sophia et al., 2018 *(A concurrent mix-method)*					
Questions	**Yes**	**No**	**Can't tell**	**Comments**	**Quality score**
5.1	✓			Clear explanation for interview and observation methods	100%
5.2	✓			Interpretation of mixed studies	
5.3	✓			Clear explanation	

APPENDIX 4: The process of attaining themes

Interview Extract	Codes
''I feel healthier and I also feel my sugar is under control when I exercise''	-Reduction in blood glucose and control of blood glucose
''Not being on medication was a stronger incentive than having a better wardrobe...' AND '...One doctor told me that I have to exercise. He checked my results and he said "I'll give you more pills if you don't exercise".' AND 'I'm kind of on a mission now to exercise because the doctor tells me she is going to put me on insulin if I don't exercise.''	
"I know that it (exercise) helps in losing weight and improving the general health condition of the body"	-reduction in weight
"I feel active if I go for a walk in the morning." "I feel active after I exercise otherwise I feel drowsy and lazy." *"I feel more alive.my energy and my life and everything, you know, I come alive after going to the gym"*	-A sense of well-being
"My heart goes out to some of my T2D friends who once looked healthy, but now they cannot even walk on their own. I don't want to get the same ordeal: that's why I do the exercise."	-Awareness of complications
I felt that I had to do something. Diabetes is really awful and the thought of the consequences really scared me. *''When my children leave for work in the car, they drop me off a little away from home where there is less traffic. They ask me to walk on roads with less traffic because they are apprehensive that I may meet with an accident or something of the sort''*	-Family support
'I do fitness twice a week with other people. Well, I do it that way because if I was to do it alone, I'd just procrastinate [...] I just have to oblige myself to do it with other people; otherwise, I'd never do it.'	Peer support, sharing experience,
"The fact that I had the trainers there. They were right there encouraging me, helping me, directing me, guiding me, they were very, very supportive. They know the equipment, and it is all new to me" "I think having your trainer, you know that if you have any problems you can just bring that up.''	Support from personal trainers

" 'It's really good to use because you can pace yourself by saying that today I'm going to walk 5–6 km, and then you can see when you've actually done it, right. And be satisfied with yourself. For me that's really, really important."	- Goal-Setting
" 'I needed them… they sat there and they watched, and they went and they checked you and they motivated me…' AND 'She was so nice, and she said, "let's go, let's go you can", because I never did exercise before and I thought I would never do it, and she always pushed me to doing it.' AND 'When somebody is looking at us… for me, I tell you the supervision and the exercise. The supervision is key.' AND 'That is why I liked the programme. You had to show because it was supervised. I had to come…"	Self-tracking
''My brother was diabetic, and had his leg amputated. I mean I should be like… hum… But some reason I am not!' AND 'I hear you my sister is diabetic, and she is on insulin, and my brother is diabetic…"	Lack of confidence
"A representative quote was, "I played basketball every day. And when I do that I never lose weight. So it's all a turn off to me"	Lack of short term outcomes
'' Time restriction. I have children, I have to take them to school, spend time with them. My wife is also working so I have to make time for my children and then I have no time left to exercise."	Taking care of childre other memberships
"I often do not have enough time to do exercise; in fact, I even decided to retire from my work to care for my elderly mother who needs my support almost constantly."	Busy schedules Home maintenance, Spending time their spouse,
"I don't really get the time to exercise. I leave for work at 7 in the morning and come back at around 6 or 7. I'm really tired when I come back so I cannot exercise."	Lack of time ,
"Before I did rehab exercises every morning, but then it hurt in my knees. For about 14 days it hurt so much in my knees that I just couldn't do it, see? But then afterwards, well, I just didn't do it as a daily routine […] It took several months to get it running again as a routine.'	Working a full time/ shift patterns job, Broken exercise routine

"I do blood tests every month but I don't know whether they are controlled because of exercise or because of the medicine"	Lack of knowledge and perception of obesity
''I might get rid of my diabetes if I exercised... But actually I really don't know what I should do.''	
"Everyone in my family is well built as I am. It is not like I gained weight in the middle I have always been on the heavier side from when I was young."	
''If I were to take part in that kind of exercise, I'd make it a condition that there were some professionals who knew what it was all about when you've got the problems I do, for instance. It's not irrelevant what I do, right? [...]. I think it's important that there's someone connected to the exercise that can tell me, "You'd better stay away from that one".'	Lack of guidance from healthcare professionals
'They don't ask you anything. They just say "are you getting exercise?" I says "Oh yes I get exercise". They don't enquire as to what type of exercise.	
"He (treating physician) told me to exercise to lose weight. But they (treating physicians) don't explain the reasons and I don't ask for an explanation either''	
'I can't ride a bicycle and walk as I used to because of problems with my legs, right? [...] So I don't do it much... It also hurts if I exercise too much.'	Comorbidities, Musculoskeletal, tiredness, Body weight, heart problems, injury, pain
'You hear you should get more exercise [...]. Yeah, yeah, I'm pretty sure I do get the exercise, but I should do more of it. But when I do more of it, well then it's hard on my knees and back.'	
'I don't do much exercise because, well mainly because I'm sore with the arthritis.''	
"When I'm sick, I'm sick. I don't have the energy to even walk so really there's no point to try to get there, I mean, you have to work 45 minutes and lift things and I just don't have the energy to do it"	
"At my relatives' place, people look upon me weirdly when I go on walks so I avoid exercising when I go out of station."	Social stigma
"I am scared that I will fall down if I walk on the roads near my house because they are maintained so poorly, there are no footpaths and there are so many potholes."	Lack of exercise places
At different times of the year, weather isn't great so I figure 'oh aye' if I do my exercise but get pneumonia on the way getting me exercise or slip on the ice which again wouldn't do me any favours I'm a bit reluctant especially in wet weather and icy weather there's that many dips in footpaths now''	Poor weather condition
"When it gets dark, I'm not saying something bad would happen, but I just don't put myself in [that situation], yes, safety concerns, everyone usually has that."	Neighbourhood insecurity

Codes	Themes
Reduction in blood glucose and control of blood glucose	**Perceived Benefits**
Reduction in weight	
A sense of well-being	
Awareness of complications	
Family, friends, or peer support,	**Social Support**
Sharing experience,	
Support from personal trainers	
Goal-Setting and self-tracking	
Comorbidities, Injury, Pain	**Comorbidities**
Musculoskeletal, tiredness	
Body weight, heart problems	
Lack of exercise places	**Environmental Barriers**
Poor weather condition	
Neighbourhood insecurity	
Taking care of children, other memberships	**Obligations**
Working a full time/ shift patterns job,	
Broken exercise routine	
Busy schedules	
Home maintenance,	
Spending time their spouse,	
Lack of time	
Lack of confidence	**Lack of Motivations**
Lack of short term outcomes	
Lack of enjoyment	
Difficulties in sustaining motivation	
Lack of knowledge	**Individual Awareness**
Lack of perception of obesity	
Lack of guidance from healthcare professionals	
Social stigma	**Social Norms**