The Barriers and Facilitators of Physical Activity Participation Among People Living with Type 2 Diabetes: A Mixed Method Systematic Review Protocol

Ozge Olbeci[1*], Aycan Celik[2], Russell Jone[1]

[1]School of Health Sciences, Bangor University, Fron Heulog, Bangor, Gwynedd, LL57 2EF, UK
[2]Florence Nightingale Faculty of Nursing, Midwifery and Palliative Care, King's College London

ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is among the leading causes of serious mortality and health burden globally. Exercise is one of the commonly suggested preventions/ interventions for T2DM. However, many adults with T2DM are not achieving the recommended levels of physical activity. The objective of this systematic review is to investigate the barriers and facilitators to physical activity among people living with type 2 diabetes.

Methods/Design: This review will be undertaken using the Preferred Reporting Items and Meta-analysis (PRISMA). The database search will be performed in MEDLINE, CINAHL, PubMed, and Web of Science. Studies included will report primary data (qualitative and quantitative) on people with T2DM (18 and over years of age). The review will be limited in English published between 2009 and 2020. A study design describing reasons for barriers, facilitators or both of physical activity among people with T2DM will be included. The risk of bias will be evaluated with Mixed-Methods Appraisal Tool (MMAT). Data synthesis will be conducted with narrative synthesis for quantitative studies, and thematic synthesis for qualitative studies followed by a mix-method synthesis to combine the previous synthesis.

Discussion: This review will provide evidence for better understanding the facilitators and barriers to physical activity among 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.

Keywords: type 2 diabetes mellitus, T2DM, physical activity, exercise, barriers, facilitators

* Correspondence to Ozge Olbeci, School of Health Sciences, Bangor University, Fron Heulog, Bangor, Gwynedd, LL57 2EF, UK. Email: zgl19rfp@bangor.ac.uk

1. Background

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, & Kaplan, 2017; Prifer, Halter, & 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 & McCoy, 2019).

In the diagnosis of diabetes is considered 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). These values to diagnose diabetes should be FPG≥ mol/L (126mg/dl) or HbA1c≥ 48 mmol/mol (equivalent to 6.5%) or 2-h PG ≥11.1 mmol/L (200 mg/dl) or RPG > 11.1 mmol/L (200 mg/dl) or IMF= 6.1- 6.9 mmol/L (110-125 mg/dl) and if measured 2-h PG <7.8 mmol/L (140 mg/dl) or IGT < 7.0 mmol/L (126 mg/dl) and if measured 2-h PG ≥7.8 and < 11.1 mmol/L (140-200mg/dl) (ADA, 2017; IDF, 2019; WHO, 2006). After anybody 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. monogenic diabetes, neonatal diabetes mellitus, and maturity onset diabetes of the young (IDF, 2019).

Type 2 diabetes mellitus (T2DM) accounting for nearly 90% of all diabetes cases is the most common type of diabetes in the world (IDF, 2017; ADA, 2015). T2DM affects mostly adult people (Forouhi & Wareham, 2019). In the people with T2DM do not properly work function loops between insulin secretion and insulin action the feedback (Stumvoll, Goldstein, & 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, & Haeften, 2005).

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, & Hamid, 2017). The evidence indicates that many cases of T2DM might be prevented with lifestyle modification although individual predisposition to T2DM depends on a strong genetic basis (Zheng, Ley, & Hu, 2018). For example, Finnish Diabetes Prevention Study and the Diabetes Prevention Program Outcomes Study in the USA have demonstrated that the benefits of lifestyle modifications might last for terms from 10 to 23 years (Lindstrom et al., 2013; Diabetes Prevention Program Research Group, 2009).

1.2 Prevalence of DM

DM is one of the most common chronic illnesses around the world, and continues to rise in numbers and importance, as changing lifestyles caused increased obesity, and decreased physical activity (Shaw, Sicree, & Zimmet, 2010). 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, & 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, & Herman, (1998) estimated that 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, & Hamid, 2017). Furthermore, the IDF (2009) was 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 report of 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 effects on quality of life, economic burden, and demand on health services (Harding et al., 2019).

1.3 The burden and complication of DM

Projected global healthcare costs to prevent and treat and prevent diabetes and its complications are projected to total at least $376 billion in 2010 (IDF, 2009). This figure was expected to exceed a total of at least $490 billion by 2030 (IDF, 2009). However, the health expenditures related to diabetes were estimated to range from $673 billion to $1,197 billion in 2015 (IDF, 2017). There was also significant growth from $232 billion to $ 727 billion in health spending related to diabetes from 2007 to 2017 (IDF, 2019). The global total diabetes related health spending will be $760 billion in 2019, and spending will increase $825 billion by 2030 and $845 billion by 2045 (IDF, 2019). Average annual health spending 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 comprised approximately 12% of the global health expenditure in 2015 (IDF, 2015).

Diabetes and its complications, which are categorised with macro vascular complications and micro vascular complications, are major cause of mortality and morbidity (Cunningham et al., 2018; Zheng, Ley, & Hu, 2018). Macro vascular complications of diabetes, including coronary heart disease, stroke and peripheral vascular disease, and micro vascular complications, such as end-stage renal disease (ESRD), retinopathy and neuropathy, along with lower-extremity amputations (LEA), are responsible for much of the burden associated with diabetes (Sjöström, Peltonen, & Jacobson, 2014; Wadhwani et al., 2020). Furthermore, T2DM is associated with psychological problems. 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 a tremendous increase in mortality and disability-adjusted life years (DALYs) around the world (Zheng, Ley, & Hu, 2018). For example, while a high fasting level of glucose was the tenth most common global risk factor for DALYs in 1990, it was ranged in the fourth most common in 2005, and the third most common in 2015 (GBD 2015 Risk Factors Collaborators, 2016). Approximately 5.0 million deaths in the world happened due to diabetes and its complications in 2015, it means that equivalent to one death every six seconds (IDF, 2015). However, the available evidence demonstrates that diabetes self-management implementations can decrease diabetes related complications and mortality risk (Byers, Garth, Manley, & Chlebowy, 2016; He et al., 2017; Litwack et al., 2013).

1.4 The significance self-management in T2DM

A self-management of T2DM requires a considerable attention to physical activity, management of diet, glucose monitoring, consistent use diabetes medication and/or insulin,

and ongoing to medical care (Cunningham et al., 2018; Gregg et al., 2007; Zheng, Ley, & Hu, 2018). A key target of diabetes self-management is the control of HbA1c, which is a quantity of average blood glucose over several months (Cunningham et al., 2018). According to IDF and ADA guidance, the target for HbA1c is <7.0 (IDF, 2019; IDF, 2017; ADA, 2017). The implementations of good self-management of diabetes reduce significantly the level of HbA1c (Litwack et al., 2013). The measurement of lower HbA1c delays the starting of peripheral vascular disease coronary heart disease, retinopathy, nephropathy, and neuropathy, which are the commonest complications of diabetes (Thomas, Alder, & Leese, 2004). The level of lower HbA1c means that likelihood of developing diabetes-related complications will decrease micro vascular illnesses by up to 37% and reduce myocardial infarction by up to 14% (U.K. Prospective Diabetes Study Group [UKPDS], 1998).

All diabetes self-management implementations (e.g. physical activity, diet, and monitoring blood glucose) have a considerable role in the control of HbA1c, and all implementations are integral components for the management of diabetes. Therefore, 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 specific knowledge about the effectiveness or the barriers/facilitators of self-management implementation for people with T2DM. Thus, this review will focus 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 & 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). People with T2DM should be recommended to practice at least 150 min/week of moderate-intensity aerobic PA (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). 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

PA has been suggested as an integral component of self- management in people with T2DM which helps decrease macro vascular complications and premature mortality (Advika, Idiculla, & Kumari, 2017; Sluik et al., 2012). PA improves body mass index, systemic inflammation, arterial stiffness, and glycaemic control (Fagour et al., 2013; Kaizu et al., 2014; Umpierre, Paila, Ribeiro, & Kramer, 2011; WHO, 2016). PA not only prevents or delays the occurrence of long-term diabetes complications such as retinopathy, nephropathy, and neuropathy, but also might decelerate the progression of existing complications (Pati et al., 2019). Moreover, PA has positive effects on glycaemic control, metabolic abnormalities, insulin action, associated with T2D (Pati et al., 2019, as cited in, Hayes & Kriska, 2008, p.1).

Therefore, PA plays a key role in the management of T2DM (Pati et al., 2019; Zheng, Ley, & Hu, 2018).

1.7 Aims and objectives

The evidence in literature supports the positive effect of PA on the glycaemic control for people with T2DM. Umpierre, Paila, Ribeiro, & Kramer, (2011); Liubaoerjijin, Terada, Fletcher, & Boule, (2016); and Cai et al. (2017) in their systematic review found that structured exercise, which comprises resistance training, aerobic exercise, or both, is associated with the decrease of HbA1c in people with T2DM, increasing exercise intensity is associated with safely the decrease of HbA1c, and there is a safe and effective of aerobic exercise on the quality of life in people with T2DM (respectively) . Umpierre, Paila, Ribeiro, & Kramer, (2011) also evaluated that structured exercise more than 150 minutes per week improves better the HbA1c.

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 function and structure along with the highest reduction in liver fat. Blankenship et al., (2019) recruited 30 sedentary people with T2DM (39-74 years old). They evaluated the effect 20, 40, or 60 min of activity on daily and postprandial-glycaemia by performing either breaks from sitting after each meal (BR) or one continuing walk 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 hyperglycaemia compared with Control ($P\leq 0.0875$). There were not any differences in the duration of hyperglycaemia of people in the BR and Control groups. Blankenship et al. (2019), concluding, evaluated that continuous walking is more effective than breaks from sitting in lowering daily hyperglycaemia in the free-living environment. Way, Hackett, Baker, & Johnson, (2016) found that regular exercise improves insulin sensitivity, which can continue for 72 hours or longer after the last exercise training. According to Way, Hackett, Baker, & Johnson, (2016), their findings support that short periods of inactivity (e.g., 72 hours) might not result in a loss of insulin sensitivity.

Although nearly all evidence support the importance of PA for people with T2DM, many studies have documented 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., 2016; Palermo & Sandoval, 2016; Vibha et al., 2018). For example, Sophia et al., (2018) found that the total intensity score of 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, & Laitinen, (2009) investigated 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: internal and external barriers. The internal barriers were related to an individual's own decision-making (lack of time), emotional (shame), and overweight. The external barriers were related to an individual's own decision-making (weather), or lack of social support. According to Korkiangas, Alahuhta, & Laitinen, (2009), these barriers can be solved 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 will be expanded by investigating both facilitators and barriers to PA among 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 PA in people living with T2DM. Thus, this systematic review aims: (i) to review evidence to better understand the facilitators and barriers to PA 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 PA. In this regard, this study will explore the following research question; What are the barriers and facilitators of physical activity participation among people living with type 2 diabetes?

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/Design

2.1 Methodologies for systematic review

This study will be 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' values, perceptions, and experiences within a single systematic review (Harden & Thomas 2005; Heyvaert, Maes, & Onghena, 2013). Mix-method reviews have a significant advantage over the synthesis of merely qualitative or quantitative studies in that they might lead to a very diverse understanding of a topic (van Grootel, Nair, Klugkist, & 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, & Altman, 2009). The study was registered in the "International Prospective Register of Systematic Reviews" (PROSPERO) in 2020 with registration number CRD42020188011.

2.2 Research question

The research question for this study is that ''what are the barriers 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. 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.

Therefore, Population, Exposure, Comparator, Outcome (PECO) will be used to detect 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 shows 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 reporting and specification of eligibility criteria are a main significant part in the systematic review process (McCrae & Pursell, 2015; Bettany & Saltikov, 2012). Eligible criteria should be explicitly reported to the reader to understand the implications and rationale for the review results (De Brun, 2013; McCrae, Blackstock, & Pursell, 2015). According to McCrae, Blackstock & Pursell, (2015), eligibility criteria should be detected with scope of literature reviewed, reporting of papers rejected or added, and usefulness of exclusion criteria. They also highlighted that eligibility criteria should be identified before the search strategy. Detecting firstly search strategy is a major risk of bias because it causes retrospective boundaries of the scope of the review, the possible for exclusion on the basis of study findings rather than legitimate criteria (McCrae, Blackstock, & 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.

For inclusion criteria are applied: (i) studies examining people living with T2DM, (ii) studies evaluating the barriers, facilities, or both to physical activity, (iii) studies published after 2009. A systematic review related to the perceived barriers (outcome) to physical activity (exposure) for type 2 diabetes mellitus (population) published in 2009 was found in the result of all screening. Therefore, the studies published after 2009 years were thought as eligible studies.

The following exclusion criteria are 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 comprehensive information about barriers and facilities of exercise. Thus, this systematic review was designed as mixed-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 disease 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 tool for exercise among type 2 diabetes.	To answer the question designed by this mix-method systematic review.
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 2009 and 2020	Before 2009 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 to be included are quantitative, qualitative and mixed method research focused on the barriers, facilitators, or both to exercise among adults with T2DM.

2.3.2 Population. Study participants will include over 18 years of age adults diagnosed with T2DM. The course of T2DM, the severity of the disease, any treatment options, the duration of T2DM, and those with or without complications will not consider as a limitation to evaluate barriers and facilities of exercise among people with T2DM. The studies involving illnesses such as cancer, stroke, heart diseases, or hypertension will be excluded. In the studies including people with T2DM and other chronic diseases are included as long as data provided by people with T2DM are separately presented from other conditions (e.g. cancer).

2.3.3 Exposure/intervention. Any study design describing reasons for barriers or facilitators of PA among adult people with T2DM will be included. PA is defined as exposure in this study. The term of PA comprises walking, swimming, running, 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 are defined; (i) Barriers to PA participation among adult people with T2DM, (ii) Facilitators of PA participation among adult people with T2DM.

2.4 Search Strategy

The development and preparation of this systematic review uses the rules of the PRISMA (Moher, Liberati, Tetzlaff, & Altman, 2009). PRISMA focuses on randomised trials; however, PRISMA might also be used as a base for reporting systematic reviews of other sorts of research, especially assessments of interventions (Moher et al., 2009). A comprehensive search of four databases will be conducted in the library databases via Library of Bangor University through the following four databases; MEDLINE via Ovid (MEDLINE from 1946 to July, 2020), Web of Science (All databases from 1950 to July, 2020), PubMed (from 1966 to July, 2020), and CIHANL (from 1806 to July, 2020). The reference lists of including studies also will be scanned in order to assemble all available data for this study.

A facet analysis will be carried out by dividing the question into three parts- population (people with T2DM), exposure (physical activity), and outcomes (perceived barriers and facilitators of exercise). A systematic database search will be carried out using a combination of Medical Subject Heading (MeSH) to attain a sensitive search. MeSH terms are arranged in a hierarchy named a tree, from broader terms to more specific terms, and these terms are updated weekly and reviewed annually (Ecker & Skelly, 2010). Truncation (*) will be used to ensure all possible word endings. The results will be combined by using the Boolean operator 'OR' in each column. After that, the results of the four columns by using the Boolean operator 'AND' will be combined to attain a comprehensive search to retrieve all relevant topics. MeSH terms and synonym terms will be determined by the terms of MEDLINE via Ovid. The following search terms and operators will be 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 (facilitator* 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		Facilitators		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	**A N D**	exercise* **OR** activity*, physical **OR** aerobic exercise* **OR** exercise*, aerobic **OR** physical exercise* **OR** exercise*, physical **OR** physical activity*	**A N D**	facility* **OR** motivation* **OR** benefit*	**A N D**	barrier* **OR** challenge*

*Truncation

2.5 Quality assessment

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 (O'Cathain, Murphy & Nicholl, 2008; Yu, 2008). Thus, 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 will be conducted with MMAT (2011 version) because this tool presents an opportunity for researchers to appraise 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 will be calculated. For example, the quality score is 3/4, meaning that three criterions are met (75%) (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).

The critical appraisal of all included studies will be conducted by two independent reviews (OO, AC). The scores of studies will be recorded by both reviews to facilitate comparison of appraisal scores. Disagreements on the quality of study will be solved with debating with a third reviewer (RJ). Studies included will not be excluded on the basis of quality, however, quality will be considered when interpreting results.

2.6 Data extraction

The data analysed in a systematic review are attained from the results extracted from personal research papers relevant to the systematic review question (Munn, Tufanaru, & Aromataris, 2014). Two standardised, pre-piloted templates will be used to undertake data extraction and assessment of study quality. One of the Joanna Bridge Institution (JBI) templates will be used for included qualitative studies in this systematic review. A second template will be used for quantitative studies (e.g. cross-sectional, case-control). After all studies are firstly screened by reviewing titles and abstract to determine appropriate studies by one reviewer (OO). After that, irrelevant titles and abstracts to research questions are removed. Relevant studies during the screening process are conducted by searching the full text of the studies. Data extraction is conducted by independent two reviewers to increase transparency. If any discrepancies arise through the process of data extraction, these will be solved by consensus and discussion with a third reviewer. The following characteristics will be extracted: author, year, study design, aim of study, country, participant demographics (e.g. age range, gender), and type of exercise exposure, sample size, main results, themes, and sub-themes. Missing data will not be requested from study authors.

2.7 Data synthesis

The mixed-method analysis will benefit the qualitative data to inform on the perceived effects, meanwhile the quantitative data will inform on the measured effects. Using meta-analysis will not be appropriate because of the heterogeneity of variation in types of subjects, tools, study designs, outcomes to PA among T2DM. Therefore, narrative synthesis for quantitative studies and thematic synthesis for qualitative studies will be used in this review. The narrative synthesize will be tabulated in a spread sheet to catch variables examined. Firstly, the characteristics of each quantitative study will be categorised, then, they will divide into different groups with each specific outcome PA involved. The findings of each study will be exhibited and synthesised to see whether they have divergent or similar findings. A thematic synthesis of results from the qualitative studies will be considered to investigate perceived barriers and facilities towards PA among people among T2DM

followed by a mix-method synthesis to combine the previous analysis. One reviewer (OO) will oversee the initial data synthesis which will then be discussed with all reviewers.

3. Discussion

This systematic review will provide a detailed summary about perceived barriers and facilitators to engage in PA for people with T2DM and will review evidence to better understand the facilitators and barriers to PA that people with T2DM. This review 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 contribute to future research and support the development of the intervention to expand and increase facilitator factors determined by people with T2DM.

References

Advika, T. S., Idiculla, J., & Kumari, S. J. (2017). Exercise in patients with type 2 diabetes: Facilitators and barriers-A qualitative study. *Journal of Family Medicine and Primary Care*, *6*(2), 288. https://doi.org/10.4103/2249-4863.219998

American Diabetes Association. (2017). 2. Classification and diagnosis of diabetes. *Diabetes Care*, *40*(Supplement 1), S11-S24. https://doi.org/10.2337/dc17-S005

Amos A. F., McCarty D. J., & Zimmet P. (1997). The rising global burden of diabetes and its complications: estimates and projections to the year 2010. *Diabetic Medicine*, *14*, S1-S85. http://www.sciepub.com/reference/59086.

Bettany-Saltikov, J. (2012). *How to do a systematic literature review in nursing: a step-by-step guide*. McGraw-Hill Education.

Blankenship, J. M., Chipkin, S. R., Freedson, P. S., Staudenmayer, J., Lyden, K., & Braun, B. (2019). Managing free-living hyperglycemia with exercise or interrupted sitting in type 2 diabetes. *Journal of Applied Physiology*, *126*(3), 616-625. https://doi.org/10.1152/japplphysiol.00389.2018

Briscoe, S., & Cooper, C. (2014). The British Nursing Index and CINAHL: a comparison of journal title coverage and the implications for information professionals. *Health Information & Libraries Journal*, *31*(3), 195-203. https://doi.org/10.1111/hir.12069

Byers, D., Garth, K., Manley, D., & Chlebowy, D. (2016). Facilitators and barriers to type 2 diabetes self-management among rural African American adults. *Journal of Health Disparities Research and Practice*, *9*(1), 9. https://digitalscholarship.unlv.edu/jhdrp/

Cai, H., Cai, H., Li, G., Li, G., Zhang, P., Zhang, P., & Chen, L. (2017). Effect of exercise on the quality of life in type 2 diabetes mellitus: A systematic review. *Quality of Life Research, 26*(3), 515-530. https://doi.org/10.1007/s11136-016-1481-5

Cassidy, S., Thoma, C., Hallsworth, K., Parikh, J., Hollingsworth, K., Taylor, R., Jakovljevic, D., & Trenell, M. (2015). High intensity intermittent exercise improves cardiac structure and function and reduces liver fat in patients with type 2 diabetes: a randomised controlled trial. *Diabetologia*, *59*(1), 56-66. https://doi.org/10.1007/s00125-015-3741-2

Chakkera, H., Kudva, Y., & Kaplan, B. (2017). Calcineurin inhibitors: Pharmacologic mechanisms impacting both insulin resistance and insulin secretion leading to glucose dysregulation and diabetes mellitus. *Clinical Pharmacology & Therapeutics, 101*(1), 114-120. https://doi.org/10.1002/cpt.546

Chen, L., Magliano, D. J., & Zimmet, P. Z (2011). The worldwide epidemiology of type 2 diabetes mellitus—present and future perspectives. *Nature Reviews Endocrinology*, *8*(4), 228-236. https://doi.org/10.1038/nrendo.2011.183

Cunningham, A. T., Crittendon, D. R., White, N., Mills, G. D., Diaz, V., & LaNoue, M. D. (2018). The effect of diabetes self-management education on HbA1c and quality of life in African-Americans: a systematic review and meta-analysis. *BMC Health Services Research*, *18*(1). https://doi.org/10.1186/s12913-018-3186-7

De Brun, C. (2013, November 7). *Finding the evidence a key step in the information production process.* National Health Service (NHS). https://www.england.nhs.uk/wp-content/uploads/2017/02/tis-guide-finding-the-evidence-07nov.pdf.

Ecker, E. D., & Skelly, A. C (2010). Conducting a winning literature search. *Evidence-Based Spine-Care Journal*, *1*(01), 9-14. https://doi.org/10.1055/s-0028-1100887

Fagour, C., Gonzalez, C., Pezzino, S., Florenty, S., Rosette-Narece, M., Gin, H., & Rigalleau, V. (2012). Low physical activity in patients with type 2 diabetes: The role of obesity. *Diabetes and Metabolism, 39*(1), 85-87. https://doi:10.1016/j.diabet.2012.09.003

Forouhi, N. G., & Wareham, N. J (2019). Epidemiology of diabetes. *Medicine*, *47*(1), 22-27. https://doi.org/10.1016/j.mpmed.2018.10.004

GBD Risk Factors Collaborators. (2016). Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990–2015: a systematic analysis for the global burden of disease Study 2015. *The Lancet, 388*(10053), 1659-1724. https://doi.org/10.1016/S0140-6736(16)31679-8

Gizaw, A. T., Ababulgu, F. A., Gebretsadik, L. A., & Abraha, G. K. (2017). The effect of psychometric variables in predicting physical activity behavior among diabetes mellitus type-2 patients. *Journal of Multidisciplinary Healthcare*, *10*, 59-64. https://doi.org/10.2147/jmdh.s122573

Gregg, J. A., Callaghan, G. M., Hayes, S. C., & Glenn-Lawson, J. L. (2007). Improving diabetes self-management through acceptance, mindfulness, and values. *Journal of Consulting and Clinical Psychology, 75*(2), 336-343. https://doi:10.1037/0022-006X.75.2.336

Harden, A., & Thomas, J. (2005). Methodological issues in combining diverse study types in systematic reviews. *International Journal of Social Research Methodology*, *8*(3), 257-271. https://doi.org/10.1080/13645570500155078

Harding, J., Pavkov, M., Pavkov, M., Magliano, D., Magliano, D., & Gregg, E. (2019). Global trends in diabetes complications: A review of current evidence. *Diabetologia, 62*(1), 3-16. https://doi.org/10.1007/s00125-018-4711-2

Hayes, C., & Kriska, A. (2008). Role of physical activity in diabetes management and prevention. *Journal of The American Dietetic Association*, *108*(4), S19-S23. https://doi.org/10.1016/j.jada.2008.01.016

Heyvaert, M., Maes, B., & Onghena, P. (2013). Mixed methods research synthesis: definition, framework, and potential. *Quality & Quantity*, *47*(2), 659-676. https://doi.org/ 10.1007/s11135-011-9538-6

Higgins, J. P., & Green, S. (2011). *Cochrane handbook for systematic reviews of interventions version 5.1.0.* The Cochrane Collaboration. https://handbook-5-1.cochrane.org/

Hill, J., Lavigne Delville, C., Auorousseau, A., Jonathan, D., Peer, N., Oldenburg, B., & Kengne, A. (2020). Development of a tool to increase physical activity among people at risk for diabetes in low-resourced communities in cape town. *International Journal of Environmental Research and Public Health*, *17*(3), 865. https://doi.org/10.3390/ijerph17030865

International Diabetes Federation (2000). *IDF diabetes atlas* (IDF Publication 1st Edition). https://www.idf.org/e-library/epidemiology-research/diabetes-atlas/24-atlas-1st-edition.html

International Diabetes Federation. (2009). *IDF diabetes atlas* (IDF Publication 4th Edition). https:// IDF-Diabetes-Atlas-4th-edition%20.pdf
International Diabetes Federation. (2015). *IDF diabetes atlas* (IDF Publication 7th Edition). https://www.oedg.at/pdf/1606_IDF_Atlas_2015_UK.pdf
International Diabetes Federation. (2017). *IDF diabetes atlas* (IDF Publication 8th Edition). https://diabetesatlas.org/upload/resources/previous/files/8/IDF_DA_8e-EN-final.pdf
International Diabetes Federation. (2019). *IDF diabetes atlas* (IDF Publication 9th Edition). https://www.diabetesatlas.org/upload/resources/2019/IDF_Atlas_9th_Edition_2019.pdf
Joseph, J. J, Echouffo-Tcheugui, J. B., Golden, S. H, Chen, H., Jenny, N. S., Carnethon, M., Jr, D., Burke, G., Vaidya, D., Ouyang, P., & Bertoni, A.G. (2016). Physical activity, sedentary behaviors and the incidence of type 2 diabetes mellitus: the Multi-Ethnic Study of Atherosclerosis (MESA). *BMJ Open Diabetes Research & Care*, *4*(1), e000185. https://doi.org/10.1136/bmjdrc-2015-000185
Kaizu, S., Kishimoto, H., Iwase, M., Fujii, H., Ohkuma, T., Ide, H., Jodai, T., Kikuchi, Y., Idewaki, Y., Hirakawa, Y., Nakamura, U., & Kitazono, T. (2014). Impact of leisure-time physical activity on glycemic control and cardiovascular risk factors in Japanese patients with type 2 diabetes mellitus. *Plos One*, *9*(6), e98768. https://doi.org/10.1371/journal.pone.0098768
Korkiakangas, E. E, Alahuhta, M. A., & Laitinen, J. H. (2009). Barriers to regular exercise among adults at high risk or diagnosed with type 2 diabetes: a systematic review. *Health Promotion International*, *24*(4), 416-427. https://doi.org/10.1093/heapro/dap031
Liubaoerjijin, Y., Terada, T., Fletcher, K., & Boulé, N. G. (2016). Effect of aerobic exercise intensity on glycemic control in type 2 diabetes: a meta-analysis of head-to-head randomized trials. *Acta Diabetologica*, *53*(5), 769-781. https://doi.org/10.1007/s00592-016-0870-0
Marcellusi, A., Viti, R., Sciattella, P., Aimaretti, G., De Cosmo, S., Provenzano, V., & Mennini, F. S (2016). Economic aspects in the management of diabetes in Italy. *BMJ Open Diabetes Research & Care, 4*(1), e000197-A603. https://doi.org/ 10.1136/bmjdrc-2016-000197
McCrae, N., Blackstock, M., & Purssell, E. (2015). Eligibility criteria in systematic reviews published in prominent medical journals: a methodological review. *Journal of Evaluation in Clinical Practice*, *21*(6), 1052-1058. https://doi.org/10.1111/jep.12448
Methley, A. M., Campbell, S., Chew-Graham, C., McNally, R., & Cheraghi-Sohi, S. (2014). PICO, PICOS and SPIDER: A comparison study of specificity and sensitivity in three search tools for qualitative systematic reviews. *BMC Health Services Research, 14*(1), 579. https://doi.org/10.1186/s12913-014-0579-0
Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine, 6*(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097
Morgan, R. L., Whaley, P., Thayer, K. A., & Schünemann, H. J. (2018). Identifying the PECO: A framework for formulating good questions to explore the association of environmental and other exposures with health outcomes. *Environment International*, *121*, 1027-1031. https://doi.org/10.1016/j.envint.2018.07.015
Munn, Z., Tufanaru, C., & Aromataris, E. (2014). JBI's systematic reviews: Data extraction and synthesis. *The American Journal of Nursing, 114*(7), 49-54. https://doi.org/10.1097/01.NAJ.0000451683.66447.89
Nouwen, A., Nefs, G., Caramlau, I., Connock, M., Winkley, K., Lloyd, C. E., & Pouwer, F. (2011). Prevalence of depression in individuals with impaired glucose metabolism or undiagnosed diabetes. *Diabetes Care, 34*(3), 752-762. https://doi.org/ 10.2337/dc1-01414

O'Cathain, A., Murphy, E., & Nicholl, J. (2008). The quality of mixed methods studies in health services research. *Journal of Health Services Research & Policy*, *13*(2), 92-98. https://doi.org/10.1258 /jhsrp.2007.007074

O'Cathain, A. (2010). Assessing the quality of mixed methods research: toward a comprehensive framework. In Tashakkori, A., & Teddlie, C. *SAGE handbook of mixed methods in social & behavioral research* (pp. 531-556). SAGE Publications. https://doi.org/10.4135/9781506335193.

Pace, R., Pluye, P., Bartlett, G., Macaulay, A. C., Salsberg, J., Jagosh, J., & Seller, R. (2012). Testing the reliability and efficiency of the pilot mixed methods appraisal tool (MMAT) for systematic mixed studies review. *International Journal of Nursing Studies, 49*(1), 47-53. https://doi.org/10.1016/j.ijnurstu.2011.07.002

Palermo, M., & Sandoval, M. A. (2016). Assessment of physical activity level among patients with type 2 diabetes mellitus at the UP–Philippine general hospital diabetes clinic. *Journal of the ASEAN Federation of Endocrine Societies, 31*(2), 144-149. https://doi.org/10.15605/jafes.031.02.10

Pati, S., Lobo, E., Pati, S., Desaraju, S., & Mahapatra, P. (2019). Type 2 Diabetes and physical activity: Barriers and enablers to diabetes control in Eastern India – ERRATUM. *Primary Health Care Research & Development*, *20*. https://doi.org/10.1017/s1463423619000689

Pluye, P., Robers, E., Cargo, M., Bartlett, G., O'Cathain, A., & Griffiths, F., Boardman, F., Gagnon, M. P., & Rousseau, M. C. (2011). Proposal: A mixed methods appraisal tool for systematic mixed studies reviews. http://mixedmethodsappraisaltoolpublic.pbworks.com/w/file/fetch/84371689/MMAT%202011%20criteria%20and%20tutorial%202011-06-29updated2014.08.21.pdf

Piercy, K. L., Troiano, R. P., Ballard, R. M, Carlson, S. A., Fulton, J. E, Galuska, D. A, George, S. M., & Olson, R. D. (2018). The physical activity guidelines for americans. *JAMA*, *320*(19), 2020-2028. https://doi.org/10.1001/jama.2018.14854

Rodriguez-Gutierrez, R., & McCoy, R. G. (2019). Measuring what matters in diabetes. *JAMA*, *321*(19), 1865. https://doi.org/10.1001/jama.2019.4310

Sami, W., Ansari, T., Butt, N. S., & Hamid, M. R. A. (2017). Effect of diet on type 2 diabetes mellitus: A review. *International Journal of Health Sciences, 11*(2), 65-71. https://www.ncbi.nlm.nih.gov/pubmed/28539866

Shaw, J. E., Sicree, R. A., & Zimmet, P. Z. (2009). Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes Research and Clinical Practice, 87*(1), 4-14. https://doi.org/10.1016/j.diabres.2009.10.007

Sigal, R. J., Kenny, G. P., Wasserman, D. H., & Castaneda-Sceppa. C. (2004). Physical activity/exercise and type 2 diabetes. *Diabetes Care,* 27(10), 2518-2539. https://doi.org/10.2337/diacare.27.10.2518

Souto, R. Q., Khanassov, V., Hong, Q. N., Bush, P. L., Vedel, I., & Pluye, P. (2015). Systematic mixed studies reviews: updating results on the reliability and efficiency of the mixed methods appraisal tool. *International Journal of Nursing Studies*, *52*(1), 500-1. https://doi.org/10.1016/j.ijnurstu.2014.08.010

Sophia, H. H., Mei, R. F., Liu, S., Lin, Y. K., & Chang, W. Y. (2018). CE: Original research physical activity among Chinese American immigrants with prediabetes or type 2 diabetes. *AJN The American Journal of Nursing*, *118*(2), 24-32. https://doi.org/ 10.1097/01.NAJ.0000530221.87469.86

Sjöström, L., Peltonen, M., Jacobson, P., Ahlin, S., Andersson-Assarsson, J., Anveden, Å., Bouchar, C., Carlsson, B., Karason, K., Lönroth, H., Naslund, I., Sjöström, E., Tauba, M., Wedel, H., Swensson, P., Sjöholm, K., & Carlsson, L. M. S. (2014). Association of bariatric surgery with long-term remission of type diabetes and with microvascular and macrovascular complications. *JAMA*, *311*(22), 2297. https://doi.org/10.1001/jama.2014.5988

Sluik, D., Buijsse, B., Muckelbauer, R., Kaaks, R., Teucher, B., Johnsen, N. F., Tjønneland, A., Overvad, K., Ostergaard, J. N., Amiano, P., Ardanaz, E., Bendinelli, B., Pala, P., Tumino, R., Ricceri, R., Mattiello, A., Spijkerman, A. M. W., Monninkhof, E.F., May, A. M., & Franks, P. W. (2012). Physical activity and mortality in individuals with diabetes mellitus. *Archives of Internal Medicine*, *172*(17), 1285. https://doi.org/10.1001/archinternmed.2012.3130

Stumvoll, M., Goldstein, B. J., & van Haeften, T. W. (2005). Type 2 diabetes: principles of pathogenesis and therapy. *The Lancet*, *365*(9467), 1333-1346. https://doi.org/10.1016/s0140-6736(05)61032-x

Thomas, N., Alder, E., & Leese, G. P. (2004). Barriers to physical activity in patients with diabetes. *Postgraduate Medical Journal*, *80*(943), 287-291. https://doi.org/10.1136/pgmj.2003.010553

UK Prospective Diabetes Study (UKPDS) Group. (1998). Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *The Lancet, 352*(9131), 837-853.

Umpierre, D., Ribeiro, P. A. B., Kramer, C. K., Leitão, C. B., Zucatti, A.T. N., Azevedo, J. M., Gross, J. L., Ribeiro, J. P.,& Schaan, B. D. (2011). Physical activity advice only or structured exercise training and association with HbA1c levels in type 2 diabetes. *JAMA*, *305*(17), 1790. https://doi.org/10.1001/jama.2011.576

Vibha, S. P., Kulkarni, M. M., Ballala, A. K., Kamath, A., & Maiya, G. A. (2018). Community based study to assess the prevalence of diabetic foot syndrome and associated risk factors among people with diabetes mellitus. *BMC Endocrine Disorders*, *18*(1). https://doi.org/10.1186/s12902-018-0270-2

Wadhwani, J. L., Chittawar, S., Gedam, U., & Khandare, S. (2020). Association between diabetic neuropathy and neutrophil lymphocyte ratio amongst type 2 diabetics. *Scholars Journal of Applied Medical Sciences*, *8*(1), 312-315. https://doi.org/10.36347/sjams.2020.v08i01.059

World Health Organization. (2004, May). *The global strategy on diet, physical activity and health (DPAS)* (Endorsed World Health Assembly). https://www.who.int/dietphysicalactivity/strategy/eb11344/strategy_english_web.pdf

World Health Organization. (2006). *Definition and diagnosis of diabetes mellitus and intermediate hyperglycaemia* (Report WHO/IDF consultation). https://www.who.int/diabetes/publications/Definition%20and%20diagnosis%20of%20diabetes_new.pdf

Yu, C. (2008). Book Review: Creswell, J., & Plano Clark, V. (2007). Designing and conducting mixed methods research. Sage. *Organizational Research Methods*, *12*(4), 801-804. https://doi.org/10.1177/1094428108318066

Zheng, Y., Ley, S. H., & Hu, F. B. (2018). Global aetiology and epidemiology of type 2 diabetes mellitus and its complications. *Nature Reviews Endocrinology, 14*(2), 88-98. https://doi.org/10.1038/nrendo.2017.151