A MIXED-METHODS EXAMINATION OF THE DIETARY AND PHYSICAL ACTIVITY CHARACTERISTICS OF OVERWEIGHT AND OBESE SOUTH ASIAN MEN LIVING IN THE UK

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I would like to dedicate this thesis to my parents,

Moloud and Ahmad Emadian-Saravi

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I would like to take this opportunity to express my appreciation to everyone who contributed to making this PhD thesis possible.

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ADA	American Diabetes Association
AE	Amir Emadian
AEE	Activity Energy Expenditure
ANOVA	Analysis of Variance
BMI	Body Mass Index
BP	Blood Pressure
CBPR	Community Based Participatory Research
CCMR	Clustered Cardiometabolic Risk
CEB	Community Energy Balance
CHO	Carbohydrate
CI	Confidence Interval
CREBH	Cyclic Responsive Element Binding protein H
CVD	Cardiovascular Disease
CYE	Clare Y England
DBP	Diastolic Blood Pressure
GI	Glycaemic Index
GIPR	Gastric Inhibitory Polypeptide Receptor
GL	Glycaemic Load
GLP-1	Glucagon Like Peptide-1
GP	General Practitioner
HC	High Carbohydrate
HFLC	High Fat Low-Carbohydrate

HGS	Hand Grip Strength
HGS	Handgrip Strength
HR	Hazard Ratio
HSE	Health Survey for England
HbA1c	Glycated Haemoglobin A1c
ICC	Interclass Correlation Coefficient
IDF	International Diabetes Federation
IFG	Impaired Fasting Glucose
IKK	Inhibitor kB Kinase
IMD	Index of Multiple Deprivation
IPAQ	International Physical Activity Questionnaire
IPAQ-SF	IPAQ Short Form
IQR	Inter Quartile Range
JBI	Joanna Briggs Institute
JLT	Janice L Thompson
JNK	Jun N-terminal Kinase
LCD	Low Carbohydrate Diet
LCKD	Low Carbohydrate Ketogenic Diet
LCM	Low Carbohydrate Mediterranean
LED	Low Energy Diet
LFD	Low Fat Diet
MET	Metabolic Equivalent of Task
MET min/wk	Metabolic Equivalent of Task in Minutes per Week
MLP	Mediterranean Lifestyle Program

MSc	Master of Science
MUFA	Mono Unsaturated Fatty Acid
MVPA	Moderate to Vigorous Physical Activity
NEFA	Non Essential Fatty Acid
NHS	National Health Service
NIDDM	Non Insulin Dependent Diabetes Mellitus
OGTT	Oral Glucose Tolerance Test
PA	Physical Activity
PAEE	Physical Activity Energy Expenditure
RCA	Rob C Andrews
RCT	Randomised Controlled Trial
SBP	Systolic Blood Pressure
SBT	Standard Behavioural Therapy
SD	Standard Deviation
SPSS	Statistical Analysis Software Package
ST	Sedentary Time
T2DM	Type 2 Diabetes Mellitus
TEE	Total Energy Expenditure
TM	Traditional Mediterranean
TNF	Tumour Necrosis Factor
UK	United Kingdom
UKDDQ	UK Diabetes and Diet Questionnaire
US	United States
VLCD	Very Low Calorie Diet

VLED	Very Low Energy Diets
VW	Victoria Wallace
WC	Waist Circumference
WHO	World Health Organization

South Asian men living in the (UK) have higher rates of Type 2 Diabetes Mellitus (T2DM) compared with their white British counterparts. Diet, physical activity (PA) and sedentary time (ST) are important risk factors for the development of T2DM. The aim of this thesis was to use a mixed-method approach to assess diet, PA and ST, as well as to explore the factors influencing these behaviours in overweight and obese South Asian men living in the UK. Study 1 revealed there is currently insufficient evidence to recommend that any specific diet is superior in improving glycaemic control, but did display the crucial role weight loss plays in the management of T2DM. Study 2 (n= 63) indicated that 54% of overweight and obese UK South Asian men had a 'healthy' diet. Results from study 3 (n=54) indicated that only 24.1% of the men met the minimum PA recommendations. Qualitative findings from study 2 and 3 revealed the unique sociocultural factors influencing diet and PA behaviours in South Asian men. The findings from this thesis can be used to advise the development of culturally tailored programmes and interventions to help reduce T2DM rates in this high-risk population.

CHAPTER 1

GENERAL INTRODUCTION

1.1 Background

Over the last 30 years, the prevalence of Type 2 Diabetes (T2DM) has risen, with an estimated 350 million people worldwide reported to be living with the condition (Danaei et al. 2011). If current trends are to continue this number is projected to rise to 438 million by 2030 (IDF 2011). In the UK alone, 2.9 million people are diagnosed with diabetes (QOF 2011), 90 % of whom have T2DM (Diabetes UK 2011). This rise in T2DM rates in the UK is a burden to the health care system, with the National Health Service (NHS) spending almost £12 billion on diabetes care in 2012 (Hex et al. 2012).

In addition to the financial costs of the disease, T2DM can have a myriad of effects on individuals. In the USA it is a leading cause of blindness in those aged between 20-74 years, along with it accounting for 60% of non-traumatic lower limb amputations (CDCP 2011). Other related conditions include polycystic ovarian syndrome and non-alcoholic fatty liver diseases (Moran et al. 2010, Renehan et al. 2010). People with T2DM also have a greater risk of developing cardiovascular disease along with associated clinical complications (Ryden et al. 2013).

South Asians are defined as people native to the Indian Subcontinent, which includes the countries of India, Pakistan, Bangladesh, Nepal and Sri Lanka (Misra & Shrivastava 2013), while Caucasians are comprised of native Europeans along with other indigenous white populations in any other countries (Misra & Shrivastava 2013). South Asians living in the UK have considerably higher rates T2DM compared to their white British counterparts, with T2DM up to six times more common in people of South Asian origin (Diabetes UK 2011).

South Asian populations also have a higher risk of developing diabetes-related complications (Vlaar et al. 2012), as well as developing the condition at a younger age compared with Caucasian populations (Chiu et al. 2011). South Asians also represent 4% of the total population making them the largest ethnic minority group in the country (Statistics UK 2008).

Obesity is an established risk factor for dysfunction in glycaemic control and the progression of T2DM (Eckel et al. 2011). Obesity typically results when energy intake exceeds energy expenditure and thus occurs when levels of physical activity (PA) are insufficiently balanced with the amount of energy consumed in the diet. Despite the acknowledgement of the central role that dietary intake has on contributing to the risk of developing T2DM, there is limited research investigating this behaviour in South Asian men. Previous studies have concentrated on assessing individual nutrient intakes in contrast to assessing diet as a whole (Misra et al. 2009), whereas others have focused on women (Sevak et al. 2004) and children (Donin et al. 2010). Furthermore, the few studies comprising of men have either focused on specific South Asian communities (Kassam-Khamis et al. 2000) or are now out-dated (Simmons and Williams 1997).

Helmrich and colleagues (1991) were among the first researchers to report evidence to show that PA on its own is a risk factor for diabetes development. Helmrich et al. used self-reported PA data to monitor activity levels of 5990 male participants over a 15-year period, highlighting the association between increased PA levels and the decreased risk of developing diabetes. Authors emphasised the role of energy expenditure associated to being more active, as the main reason behind the protective effect. It has been consistently reported that South Asians self-report being less physically active compared with other ethnic populations (Lip et al. 1996, Hughes et al. 1990). In particular, data has shown that South Asian women are particularly physically inactive (Palaniappan et al. 2002, Lean et al. 2001). There appears to be a wide variation in self-reported PA levels among South Asian adults, both within and between different countries (Ranasinghe et al. 2013). However, there is limited data published on objectively measured PA of South Asians (Babakus & Thompson 2012).

1.2 Aims and Objectives:

The aim of this PhD was to use a mixed-methods design to examine the following:

1) To determine if there is a superior dietary intervention (most effective at reducing blood glucose levels) for improving glycaemic control in overweight and obese adults with T2DM, beyond the effect of weight loss by conducting a systematic review of the current literature.
2) To assess the dietary intake of UK South Asian men who are at risk of T2DM, by using the UK Diabetes and Diet Questionnaire (UKDDQ).
3) To quantify levels of PA and sedentary time (ST) in South Asian men who are at risk of T2DM using the International Physical Activity Questionnaire (IPAQ)-long form and accelerometery.
4) To assess the comparability of self-reported and objectively measured PA and ST in South Asian men who are at risk of T2DM.
5) To understand the key factors that influence dietary choices and eating behaviours in South Asian men who are at risk of T2DM by using semi-structured interviews.

6) To understand the key factors that influences the PA and sedentary behaviours of South Asian men who are at risk of T2DM by using semi-structured interviews.

The long-term objectives of this research were to:

- Provide evidence to assist in directing the development of culturally tailored methods for assessing PA and ST in South Asian populations.
- To provide a more in-depth understanding of the factors affecting the ability of South Asian men to make positive dietary changes and be regularly physically active to reduce their risk for T2DM.

1.3 Research Questions:

The research questions examined in this PhD are:

RQ 1. Is there an ideal diet for optimising glycaemic control in overweight/obese adults with T2DM?

RQ 2. What are the current dietary intake patterns of overweight and obese UK South Asian men who are at risk of developing T2DM?

RQ 3. What are the barriers and facilitators to making positive dietary changes in overweight and obese UK South Asian men who are at risk of developing T2DM?

RQ 4. What are the levels of objectively measured PA and ST among overweight and obese UK South Asian men who are at risk of developing T2DM?

RQ 5. Are self-report methods comparable to objective methods for measuring PA and ST in these men?

RQ 6. What are the barriers and facilitators to engaging in PA that are reported by overweight and obese UK South Asian men?

CHAPTER 2

LITERATURE REVIEW

This chapter provides an overview of the literature on the prevalence and contributors to Type 2 Diabetes (T2DM), as well as briefly describing the methods used to diagnose this condition. Studies of the various types of diets that have been used to optimise glycaemic control in people with diabetes are also presented. Data on the prevalence of T2DM in South Asian men, in addition to research examining diet and physical activity in this population, are also presented.

2.1. An overview of Type 2 Diabetes and the factors contributing to it

This section presents an overview of Type 2 Diabetes and explores the factors, which contribute to its development.

2.1.1 Pathogenesis of Type 2 Diabetes

Type 2 Diabetes (T2DM) is a condition which occurs when a person's blood glucose levels become too elevated. T2DM can be viewed as a dysfunction in the body's control of energy balance and weight (Nolan et al. 2011), with insulin resistance regarded as a key underlying contributor to the development of T2DM (Reaven 1988). Obesity is associated with decreased insulin sensitivity (Bak et al. 1992), yet being obese and insulin resistant will not immediately or necessarily lead to a person developing T2DM. The condition arises only when pancreatic islet beta-cells fail to overcome the decrease in insulin sensitivity (Kahn 2001). Nutrient-induced damage of islet beta-cells is also implicated in the pathogenesis of T2DM (Prentki & Nolan 2006). Visceral adipose tissue can be expanded by continual overfeeding, which leads to increased non-esterified fatty acids (NEFA) along with various inflammatory cytokines being released, which adversely affect the insulin signalling cascade (Ravussin & Smith 2002). As a result of chronic excess energy intake, adipocytes experience hypertrophy, which can cause the endoplasmic reticulum to elicit the unfolded protein response (UPR) (Cusi et al. 2010). This triggering of the UPR leads to the stimulation of various pathways including cyclic AMP- responsive element binding protein H (CREBH), c-Jun N-terminal kinase (JNK) and inhibitor kB kinase (IKK)/nuclear factor kB (NF-kB), which act to give rise to an inflammatory reaction in the fat cells (Cusi et al. 2010). Conversely, a reduction in body weight has been shown to reduce the levels of inflammation and consequently reduce the detrimental effects of on insulin sensitivity (Gregor et al. 2009).

2.1.2 Diagnosis of Type 2 Diabetes

Both the ADA and the WHO recommend using a HbA1c (Glycated Haemoglobin A1c) concentration of over 6.5% to diagnose T2DM (WHO 2011, ADA 2010) (see Table 2.1). HbA1c is a measure of glycated haemoglobin, which reflects average plasma glucose levels over the previous 8-12 weeks (Nathan et al. 2007), and this measure can be obtained anytime of the day with no need for the patient to be fasted (WHO 2011). Other measures that can be used to diagnose T2DM include (see Table 2.1):

1) a fasting plasma glucose concentration of 7.0 mmol/L or more; and

2) a 75g oral glucose tolerance test (OGTT) with a reading of 11.1 mmol/L or more.

The OGTT involves measuring plasma glucose responses before and during the 2-hour period after the patient has consumed 75g of glucose in a fasted state (Metter et al. 2008) (see Figure 2.1). As defined by the ADA, Impaired Fasting Glucose (IFG) is a state in which glucose levels are not high enough to meet the criteria for diabetes, but are still too high to be classified as normal (ADA 2006). Impaired Glucose Tolerance is defined as an elevated 2-h plasma glucose concentration after a 75g glucose load during an OGTT (Nathan et al. 2007). Individuals with IFG and/or IGT are sometimes referred to as having pre-diabetes (ADA 2011).

Table 2.1 Criteria for diagnosis of varying levels of glycaemia and hyperglycaemia (Maki et al 2009).

Condition	**OGTT mmol/L**	**Fasting Glucose mmol/L**	**HbA1c %**
Normal	< 7.8	< 6.1	< 6.0
IFG	< 7.8	>/ 6.1 and < 7.0	6.0-6.4
IGT	>/ 7.8	< 7.0	6.0-6.4
Diabetes Mellitus	>/ 11.1	>/ 7.0	>/ 6.5

OGT = Oral Glucose Tolerance
IFG = Impaired Fasting Glucose
IGT = Impaired Glucose Tolerance
HbA1c = Glycated Haemoglobin A1c

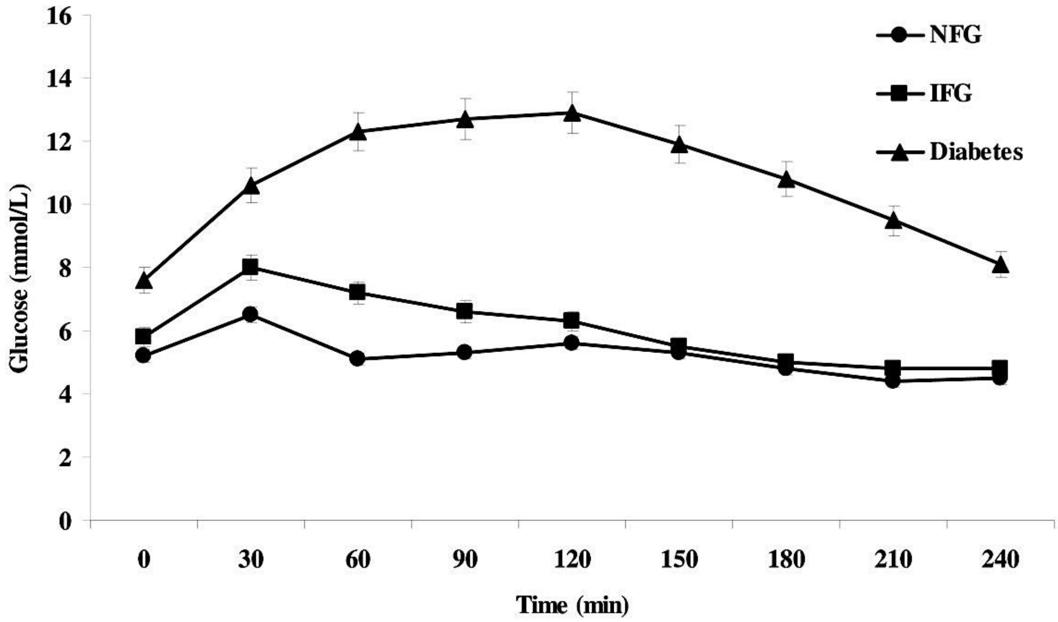

Figure 2.1 Graph showing an example of OGTT results for a participant with diabetes, with impaired fasting glucose (IFG) and normal fasting glucose (NFG) (Maki et al. 2009)

2.1.3 The role of obesity in Type 2 Diabetes

Obesity is recognised as a key risk factor for developing T2DM (Wild & Byrne 2006), with the majority of individuals with this disease being obese (BMI > 30.0 kg/m^2) (Eckel et al. 2011).Reports published by the World Health Organization (WHO) estimate that there are a total of 1.9 billion people worldwide who are classified as overweight, with 600 million of these being in the obese category (WHO 2014). This current rise in obesity is also correlated with lower levels of physical activity (Fuster & Kelly 2010). In the UK, obesity rates are higher when compared with other countries in Western Europe (Jebb 2004), with rates doubling in last 25 years to the point where nearly 26% of men and just over 24% of women were classified as obese in England during 2011 (HSE 2013).

Once thought of as only a concern for high-income countries, obesity is now a principal contributor to various chronic diseases globally (Finucane et al. 2011). The surge in obesity levels observed in low-and-mid-income countries can be linked to a combination of increased global trade, along with rapid urbanisation, leading to a modification in dietary patterns. These subsequent changes have resulted in increases in total energy consumption and reductions in PA levels (Popkin 2006). One outcome of globalisation has been the introduction of cheaper food, which is often lower in nutritional quality but higher in energy content, a combination that inevitably promotes weight gain (Malik et al. 2013).

2.1.4 The role of genetics in Type 2 Diabetes

An individual's genetic makeup is also a risk factor for T2DM, with the hereditary rate involved in the development shown to be greater than 50% (Herder & Roden 2011). Hemminki et al. 2010 conducted an extensive study demonstrating that the relative probability of T2DM was highest in those who had at least two affected siblings, irrespective of whether their parents had the condition. However, authors did not report whether these siblings were overweight/obese, which could have also impacted their risk of developing T2DM. Recent genomic studies have identified more than 40 diabetes-related loci (Nolan et al. 2011), of which the loci TCF7L2 (linked with pancreatic beta-cell dysfunction) being the most compelling regarding increasing one's susceptibility.

2.1.5 The role of diet in Type 2 Diabetes

Dietary intake, including energy content and nutrient composition, is recognised as a major contributor to both the development and management of T2DM. Currently there is debate over exactly which diet is superior for improving glycaemia for individuals with T2DM. Despite this debate, diabetes organisations have published ‘healthy eating’ guidelines for patients to adhere to.

Table 2.2. Comparison of the key dietary guidelines published by the ADA and Diabetes UK, for patients with T2DM.

	ADA	**Diabetes UK**
Macronutrient composition of diet	Do not specify	Do not specify
Dietary fibre	14g/1000kcal/day	>30g/day
Use of GI/GL diets	Insufficient evidence for use	Modest benefit of 0.5% reduction in HbA1c
Fish consumption	At least twice/week	At least twice/week
Saturated fat intake	<7% of energy from saturate fat	Advice to replace saturated fats with unsaturated fats

ADA = American Diabetes Association
GI = Glycaemic Index
GL= Glycaemic Load
HbA1c = Glycosylated haemoglobin A1c

For instance, the American Diabetes Association (ADA) guidelines do not specify exact macronutrient compositions that should be consumed but do make general recommendations (Evert et al. 2013). These include embracing a dietary pattern where the majority of carbohydrates are obtained from whole grains, vegetables, legumes (pulses), fruit, and low-fat milk. The importance of a sufficient fibre intake is highlighted, with a recommendation of at least five portions of fruits and vegetables a day encouraged to help achieve the target of 14g of fibre/1000 kcal per day. Specific guidelines are stated for fats, with a limit of 7% of total energy to come from saturated fats, a minimum consumption of trans fats, along with a minimum of 2 servings of oily fish per week. No advice is given for protein intake, with recommended levels the same as for the general population (15-20% of energy). The ADA's position on diets with a low glycemic index (GI) and glycemic load (GL) is that there is insufficient evidence of their benefits for recommending their use. These diets will be discussed in more detail later in this literature review.

Diabetes UK (2011) has also published dietary guidelines, stating that weight management ought to be the fundamental approach in regulating glucose control in T2DM for people who are overweight or obese. With regards to the effects of different macronutrient profiles of the diet, they state that for achieving optimal glycaemic control, dietary tactics should be focused on total energy consumption as opposed to the individual macronutrient sources of energy in the diet. Based on the findings from a Cochrane systematic review (Thomas & Elliot 2009), Diabetes UK acknowledges that a low GI diet may provide a modest benefit of a 0.5% reduction in HbA1c. Diabetes UK also promotes the reduction of saturated fatty acids and replacing them with favourable unsaturated fats, primarily mono-unsaturated fats. Similar to the ADA, Diabetes UK recommends limiting trans fat while promoting the consumption of at least two portions of oily fish a week.

2.2 Diets of varying macronutrient profiles

As previously mentioned, there is currently a deliberation surrounding the role of the macronutrient profile in optimal glycaemic control and effective treatment of T2DM. This review examines the relationship between diets with a range of macronutrient profiles and their subsequent effects on glycaemic control in T2DM, to see whether there is evidence to support more specific dietary guidelines for the management of this disease.

2.2.1 High carbohydrate-low fat diets

This section will provide an overview of the evidence related to high-carbohydrate-low fat diets and their effect on the prevention and treatment of T2DM.

2.2.1.1 Observation studies

The focus on high carbohydrate diets has mainly been on the potential positive effect of increased whole grain consumption in contrast to the potential negative effect of increased refined sugars on glycaemic control. The benefits of whole grain intake and reduced risk of T2DM is in part believed to be closely linked to the increase in fibre intake affiliated to a diet rich in whole grains. A proposed mechanism by which dietary fibre may improve glycaemic control is associated with the ability of soluble fibres to slow down the absorption and digestion of carbohydrates, which can lower the requirement for insulin (Slavin et al. 1999). Furthermore, insoluble fibre can be beneficial in decreasing transit time through the gut, which may reduce total time for carbohydrate absorption (Anderson et al. 1986).

The Iowa Women's Health Study reviewed 1141 self-reported cases of diabetes over a 6-year follow-up period in a cohort of postmenopausal women. After adjusting for non-dietary confounding factors such as smoking, education and age, they concluded that total carbohydrate intake was not associated with the risk of developing T2DM. However, the intake of whole grains was associated with a significant inverse relationship to developing T2DM (Meyer et al. 2000). However as dietary fibre intake was not adjusted for, the inverse relationship observed may have been due to the increased dietary fibre intake associated with higher whole grain consumption.

Sun and colleagues compared the effects of white and brown rice consumption and the risk of developing T2DM (Sun et al. 2010). Data was examined from the Health Professionals Follow-up Study and the Nurses' Health Study 1 and Study 2. The cohorts consisted of 39 765 men and 157 463 women, with results showing that once multivariate adjustments were made for influencing factors, higher intakes of white rice (more than 5 servings/ week vs. less than 1/month) were associated with an increased relative risk of developing T2DM (RR=1.17; 95% CI, 1.02-1.36). Conversely, a higher intake of brown rice (more than two servings per week vs. less than 1/ month) was linked to a reduced relative risk of diabetes (RR=0.89; 95% CI, 0.81-0.97). The authors estimated that replacing 50g/day of uncooked white rice with an equivalent amount of brown rice could reduce the relative risk of developing T2DM by 16% (RR= 0.84; 95% CI, 0.79, 0.91). This large cohort provides an insight into the possible effects of replacing white rice with a whole grain variety in T2DM. However, as they did not control for fibre intake, the benefits of brown rice may have been from the increase in fibre intake which itself has been shown to improve glycaemia (Post et al. 2012), and not specific to the rice per se. It would be of interest to compare the effects of white or brown rice in participants whose total dietary intake of fibre were similar, as this would enable researchers to examine whether there are in fact protective components in brown rice, or whether total fibre intake was the reason behind the observed differences seen in this study.

In a similar cohort study, researchers followed 2286 men and 2030 women aged between 40-69 years and gathered data on food consumption via dietary history interviews (Montonen et al. 2003). After a 10-y follow-up, 54 men and 102 women from the cohort were diagnosed with T2DM. Analysis of dietary data showed that increased whole grain consumption reduced the risk of T2DM. The relative risk between the highest and lowest quartiles of whole grain intake was 0.65 (95% CI, 0.36-1.18, p=0.02). Researchers also examined cereal fibre intake, which also appeared to reduce the risk of T2DM, with the relative risk among the extreme quartiles of cereal fibre intake being 0.39 (95% CI: 0.20, 0.77 p=0.01). Authors concluded that due to the similar effects of cereal fibre, the benefits of whole grain consumption might be in part related to the increased cereal fibre intake. Furthermore, as diet was self-reported

2.2.1.2 Randomised controlled trials

A 2009 study by Brehm et al. investigated the effects of either a high monounsaturated fatty acid (MUFA) or high carbohydrate (CHO) diet on body weight and glycaemic control in 124 overweight or obese participants (92 white and 32 African Americans) with T2DM. Forty-six men and 78 women with a mean age of 56.5 years were randomly assigned to either one of the diets for a 52-week period. Dietary intake was assessed by food diaries, which were analysed by dieticians to ensure the prescribed food plans were being adhered to. Participants were issued with customised meal plans set to a calorie deficit of 200-300 kcal/day to allow for modest weight loss. Protein and saturated fat intakes were similar for both groups. Anthropometric measurements along with blood samples were taken at baseline and regular intervals throughout the year. Authors reported similar weight loss in both groups (4.0 ± 0.8kg vs. 3.8 ± 0.6kg). HbA1c and fasting glucose levels showed comparable improvements in both the high MUFA and the high carbohydrate groups, with no statistical differences between the groups. This study demonstrated the benefits of modest caloric restriction over the course of 52 weeks in overweight and obese patients with T2DM, regardless of the differences in the prescribe macronutrient profile of the diets. The data produced appears to support the idea that total energy restriction may be of more importance than macronutrient ratios for individuals with T2DM.

Similarly, Guldbrand et al. 2012 investigated the effects of either a low-carbohydrate or low-fat diet on 61 overweight participants with T2DM. The study was a prospective randomised, parallel trial based on 4 group meetings to achieve compliance. Weight and HbA1c measurements were used to assess the effectiveness of the interventions. Participants were randomly assigned to either a low-fat diet (LFD) with 55-60% energy coming from carbohydrates or a low-carbohydrate diet (LCD) with 20% energy coming from carbohydrates. Results showed that at the end of the intervention both groups lost weight, with the mean weight lost in the LFD being 2.97 ± 4.9kg compared to 2.34 ± 5.1kg in the LCD, with no statistical difference in weight loss between the two groups ($p=0.33$). HbA1c was reduced only in the LCD, with results indicating that the LCD provided additional benefits to glycaemic control independent of weight loss, as similar weight lost in the LFD did not equate to improvements in HbA1c. Investigators had prescribed the same energy content in both diets, with 1600 kcal/day for women, and 1800 kcal/day for men. However based on the mean BMI of 32.7 ± 5.4 kg/m^2, the reported weight loss of 2.97 ± 4.9 kg in the LFD compared to 2.34 ± 5.1 kg reported in the LCD is lower than what would be expected over a 24-month period, suggesting that participants did not strictly adhere to the diet prescription. The authors stated that a dietitian provided recipes to use as meal suggestions, with participants being provided with weighing scales and notebooks to record their food intake. Participants also attended group information meetings, with four sessions taking place over the course of the 24 months. A possible limitation of the study could be the reliance on self-reporting, which may explain why weight loss over the 24 months was modest, with respect to the set caloric intakes prescribed by the dietitian (authors did report lower compliance in the LCD). Furthermore the long duration of the intervention may have made compliance more challenging. Although HbA1c decreased in the LCD only, this was seen at six months, and levels gradually increased back to baseline after that. The results of this study demonstrate that both LCD and a LFD can provide similar weight loss in overweight adults with T2DM. The results also appear to suggest a possible benefit on glycaemic control in the LCD compared with the LFD, but due to limitations in study design and problems with compliance, additional research is needed to better understand the relationship of weight loss vs. macronutrient ratios on improvements in glycaemic control.

Christensen et al. 2013 conducted a randomised control trial with two parallel groups looking at the effects of fruit consumption on patients with newly diagnosed T2DM. The study included 63 men and women who were randomly assigned to either a ‘High Fruit’ group, who received medical nutritional therapy along with instructions to consume at least 2 pieces of fruit a day, or a ‘Low Fruit’ group who received the same medical nutritional therapy along with recommendations to eat no more than two pieces of fruit daily for a 12 week period. Fruit intake in both groups was determined using 3-day food diaries along with dietary recalls. At the end of the intervention, the participants in the ‘High Fruit’ group increased their fruit consumption by 125 grams compared to those in the ‘Low Fruit’ group who

decreased their consumption by 51 grams, with a significant difference in total fruit consumption observed between both groups. Both groups showed significant reductions in waist circumference, body weight and HbA1c. HbA1c reduced by 0.49 ± 0.2 and 0.29 ± 0.1 % in the High-fruit and Low-fruit groups respectively. Body weight reduced by 2.5 ± 0.5 and 1.7 ± 0.5 kg in the High-fruit and Low-fruit groups respectively. Waist circumference reduced by 4.3 ± 0.6 and 3.0 ± 0.6 cm in the High-fruit and Low-fruit groups respectively. However, there were no significant differences in body weight, waist circumference or HbA1c between the two groups. The study exhibited no effect of increased fruit consumption on HbA1c. However as all participants lost body weight and showed glycaemic improvements, it can be suggested that energy restriction may have been an important factor. The authors stated that they did not measure total energy intake, but only advised all participants to restrict energy intake. They also argued that as weight changes and physical activity between the groups were similar, it could be assumed that energy intake would also have been similar. Christensen and colleagues have provided evidence to support the idea that fruit does not need to be restricted in people with T2DM, however whether consuming more than the two portions of fruit provided in this study would have a different effect is still unknown. What is clear is that advice to restrict energy intake was successful as participants lost weight. Therefore any improvements in HbA1c may be related to the reduction in body weight.

In 2012, Krebs and colleagues conducted the Diabetes Excess Weight Loss (DEWL) trial, comparing the effects of a low-fat high-protein diet relative to a low-fat-high carbohydrate diet. The DEWL trial was a blinded randomised control trial, which was completed by 419 participants with T2DM. It involved a 12-month intervention in which participants attended 18 one-hour group sessions lead by a dietitian, in which dietary advice and guidelines were provided. Participants were randomly allocated to either a high protein diet consisting of 30% of energy from protein, 40 % of energy from carbohydrates and 30% of energy from fat, or a high carbohydrate diet in which 15% of energy came from protein, 40 % of energy from carbohydrates, and 30% of energy from fat. Although both groups lost weight (2-3 kg, $p<0.001$) and reduced waist circumference (2-3 cm, $p< 0.001$), there were no significant differences in between the two groups after the 12-month intervention or at the 24-month follow-up. Both groups achieved significant reductions in HbA1c after six months, but there were no statistically significant differences between groups.

The authors of this study concluded that in a ‘real life’ setting the prescription of a low-fat diet high in protein had similar effects on weight loss compared with a low-fat high carbohydrate diet in overweight patients with T2DM. This study had some key limitations. Through food records it was apparent that the high protein group did consume more protein than the high carbohydrate group. However only 6% of the participants in the high-protein group achieved the target of consuming 30% of energy from protein at 6-months into the intervention. Food records also showed that the high carbohydrate groups were consuming a higher percentage of energy from carbohydrates compared with the high protein group, although they failed to achieve the 55% of energy intake target, which was initially prescribed. Results showed that both diets resulted in a statistically significant reduction in HbA1c. Krebs et al. discussed the importance of flexibility in macronutrient composition when trying to achieve weight loss. Although the study had some compliance issues, in particular with an under-consumption of protein in the high protein group, there were significant differences in the intake of both carbohydrate and protein between the two groups to be able to distinguish between the two diets. The study demonstrated support for the idea that total calorie restriction may be of a higher importance than macronutrient composition, but more importantly that weight loss itself maybe be critical for glycaemic improvements. Furthermore, this study also highlights the limitations of dietary randomised controlled trials that rely on self-reported food intake, as the prescribed diets are often not fully adhered to.

Looking at the problem from a genetic perspective, Qi et al. 2012 investigated the effects of weight loss diets differing in macronutrient levels on Gastric Inhibitory Polypeptide Receptor (GIPR) variant rs2287019, which has been associated with obesity and glucose metabolism. GIPR rs2287019 was genotyped in 737 participants who were randomly assigned to one of four diets for a 2-year period.

- Diet 1: consisting of 20% of energy from fats, 15% from protein and 65% from carbohydrates

- Diet 2: consisting of 20% of energy from fats, 25% from protein and 55% from carbohydrates

- Diet 3: consisting of 40% of energy from fats, 15% from protein and 45% from carbohydrates

- Diet 4: consisting of 40% of energy from fats, 25% from protein and 35% from carbohydrates

Self-reported dietary records along with biomarkers of adherence (respiratory quotient and urinary nitrogen) were used to confirm that changes to the macronutrient consumption prescribed had occurred. However, participants did not meet target levels in all groups. Results showed that at 6-months into the intervention, the T allele of rs2287019 was associated with greater weight loss and greater decreases in both fasting insulin and glucose in participants following a low-fat diet. Authors concluded that the T allele of GIPR rs2287019 is associated with greater improvements in glucose regulation in participants who were on a high carbohydrate, low fat and high fibre diet. Unfortunately information about energy intakes of the diet groups was not provided. Although a limitation was the lack of direct control of the energy consumption of the diets, this genetic approach to dietary interventions is an area of interest for future work.

In 2009, Barnard and colleagues compared the effects of a 'low-fat vegan diet' to a 'conventional diabetes diet' on markers of glycaemia and body weight over a 74-week period. A total of 99 participants with T2DM took part in the study, with 49 randomly assigned to a low-fat vegan diet and the other 50 prescribed a conventional diet. HbA1c and weight were measured at baseline and again at various stages throughout the intervention. Significant weight loss was achieved in both the low-fat vegan group (4.4 kg) and the conventional diet group (3.0 kg). However, there were no statistically significant differences in weight lost between the diets (p=0.25).

The vegan diet in this study consisted of ~ 10 % of energy from fat, 15% of energy from protein and 75% of energy from carbohydrates composed of grains, vegetables, legumes and fruit. Participants on this diet were also asked to avoid animal products and fatty foods, such as added oils, nuts, seeds and avocados. They were further instructed to consume more low GI foods, such as beans and green vegetables. The conventional diet was based on the 2003 recommendations made by the American Diabetes Association, which consisted of 15% of energy coming from protein, 60-70 % coming from carbohydrates and mono-unsaturated fatty acids, and <7 % of energy in the form of saturated fatty acids. In this group, participants who were overweight (BMI > 25) were prescribed diets, which were 500-1000 kcal below their maintenance calories. Participants in both groups were also asked not to modify exercise behaviours for the first 22 weeks of the intervention. Weekly 1-hour group sessions were used to give nutritional information and cooking instructions to each of the groups. Techniques such as random phone calls to conduct 24-h food recall, along with 3-day weighed food diaries were used to assess adherence to the diets.

HbA1c changes from baseline to endpoint (before medical intervention) were 0.01 for the 'conventional diet' and -0.40 for the 'low-fat vegan diet', which was statistically significant (p=0.03), with authors concluding that the low-fat vegan diet was more effective than the conventional diet, even though weight loss between groups was not statistically different between groups. Results indicated that fibre intake increased to a greater extent in the vegan group compared with the conventional group, which may be the reason for the observed benefits of the diet (Post et al. 2012).

2.2.1.3 Systematic reviews/ Meta-analyses

In 2012, Post and colleagues conducted a meta-analysis of randomised controlled trials that used an increase in fibre as an intervention for patients with T2DM. All studies used either HbA1c or fasting blood glucose as an outcome measure. Results from the 15 studies included in the analyses showed that an overall mean difference of 18.3g fibre versus placebo led to a 0.85 mmol/L reduction in fasting blood glucose (95% CI, 0.46-1.25), with the overall mean decrease in HbA1c between fibre versus placebo being 0.26% (95% CI, 0.02-0.51). This meta-analysis demonstrated the benefit of increased fibre intake for patients with T2DM. The authors stated that 8 out of the 10 trials which used HbA1c as an outcome measure lasted less than 12 weeks. As HbA1c is a measure of glycaemic control for a 12-week period, this may help to explain why increased fibre intake had a greater effect on fasting plasma glucose compared to HbA1c. Future meta-analyses should consider including studies of longer duration so that a more representative effect on HbA1c can be assessed (Post et al. 2012).

2.2.2 Moderate to high-fat diets:

This section provides an overview of the evidence examining the effects of high-fat diets diet on the prevention and treatment of T2DM.

2.2.2.1 Observation studies

Dietary fat intake is a potentially modifiable component of diet when considering T2DM risk and management. Total fat intake has been shown to have a positive association with hyperglycaemia in prospective (Marshal et al. 1994) and cross-sectional studies (Storn et al. 1992). However specific fatty acids have shown potential to have positive effects on glycaemia, for example, the U.S Nurses' Health Study demonstrated a reduced risk of developing T2DM with increased polyunsaturated fat intake (Salmeron et al. 2001). An explanation for the association between total fat intake and T2DM may be related to the increased risk of obesity in those consuming high-fat diets (Storlien et al. 1996), with obesity itself being positively associated with insulin resistance (DeFronzo et al. 1991).

The EPIC-Norfolk study further examined the effects of fat intake and glycaemia. In this cross-sectional study, 2,759 men and 3,464 women aged between 40-78 years without any previous history of T2DM were studied, and results showed that HbA1c levels were negatively linked with the polyunsaturated-to-saturated fat ratio (beta = -0.0338 HbA1c % per SD change in P:S ratio; $p<0.001$). Authors also reported that total fat intake was positively associated with increased HbA1c levels (beta = 0.0620 HbA1c % per SD change in total fat intake; $p<0.001$) (Harding et al. 2001).

2.2.2.2 Randomised controlled trials

Hussain and colleagues investigated the effect of a low enrgy diet (LED) compared with a low-carbohydrate ketogenic diet (LCKD) consisting of 20-30g of carbohydrates per day, on glycaemic control in 363 overweight and obese participants. Of the 363 participants, 102 had T2DM. The study consisted of a 24-week non-randomised intervention in which participants chose either a LED or LCKD based on personal preference. Various parameters including BMI, blood glucose level and waist circumference were measured at baseline and again at 4, 8, 12, 16, 20 and 24 weeks into the intervention. Authors concluded that both diet groups showed improvements in all parameters that were measured, but changes were more significant in the LCKD, concluding that the LCKD was more effective than the LED ($p<0.001$). Participants in the LCKD were advised to consume ~ 20g of carbohydrates a day. Intake of meat, poultry, fish and eggs were not limited, with targets set for consuming 2 cups of vegetables a day, and 100-120g of hard cheese a day, along with advice to take a daily multivitamin/multimineral. Participants on the LCKD received diet advice every other week, and if they developed signs of cravings or reached weight loss goals, they were advised to increase their carbohydrate intake by 5 g/day each week as long as they continued to lose weight.

In contrast, those in the LED were given a sample menu consisting of 2200 kcal/day, along with take home food records for self-reporting intake. As with previous studies discussed, a common limitation of these intervention studies is a lack of caloric control in both groups. The LCKD was not controlled for energy intake but only controlled for food choice. The mean weight loss was 6% of initial body weight in the LED compared with a loss of 12.2% in the LCKD. Therefore it cannot be said with certainty whether greater improvements in HbA1c were due to the ketogenic nature of the diet or due to the fact that participants in the LCKD were, in fact, consuming fewer calories and so lost more weight, with the decreased adiposity being a factor for glycaemic improvements. Furthermore as this study was non-randomised it was open to participant bias, with participants more likely to choose the dietary intervention they were more likely to adhere to. It is also important to note that 35.5% of the LCKD group had T2DM, compared to 16.8% in the LED; so future studies could consider whether individuals with T2DM are affected differently by ketogenic diets compared with those who do not (Hussain et al. 2012).

Westman et al. 2008 examined the effects of a low carbohydrate ketogenic diet (LCKD) compared to a low-GI diet. Forty-nine obese patients with T2DM completed the 24-week randomised controlled trial. Patients were either randomised to a LCKD or a low-GI diet. Patients in the LCKD were advised by a dietitian to consume less than 20g of carbohydrates a day, although they were not given daily energy intake targets but were only given instructions on which food groups to avoid and which ones they could consume unrestricted. Patients on the low-GI diet were given dietary plans to create a 500 kcal deficit according to each patient's maintenance energy values, and were also encouraged to consume a 55 % carbohydrate diet. At the end of the 24-week intervention patients in both groups lost weight and reduced their HbA1c levels. Those in the LCKD demonstrated the greatest reduction in body weight (-11.1kg vs. -6.9 kg p=0.008) and the greatest reduction in HbA1c (-1.5% vs. -0.5%, p=0.03). Authors concluded that the LCKD was more effective in improving HbA1c than the Low GI diet. The strength of this study compared to the previous study by Hussain et al. 2012 was that the patients were randomised to either group.

As seen in previous studies examined in this review, there is the issue of the magnitude of weight loss and the observed improvements in HbA1c levels. From the weight loss reported by Westman and colleagues, it is clear that energy intakes were not similar in the groups, with those in the LCKD losing significantly more weight, which was also reflected in the significantly greater HbA1c reductions seen in the group. The patients in the LCKD were not restricted in energy intake, but by the food groups they were permitted to consume. From the data, it can be assumed that due to the various restrictions placed in the LCKD, they ended up consuming fewer calories than the Low GI diet group, and hence lost more weight. In conclusion, the LCKD was more effective in helping patients lose more weight and so benefited from a greater reduction in HbA1c levels. But what is not clear is whether the actual macronutrient distribution of the LCKD had any unique benefits on glycaemic control compared to the low GI diet.

Saslow et al. 2014 compared a 3-month dietary intervention of a medium carbohydrate, low-fat, calorie-restricted, carbohydrate counting diet (MCCR, n =18) with a very low carbohydrate diet, high-fat non-calorie restricted diet (LCK, n = 16). Patients were overweight or obese and either had prediabetes or T2DM. At the end-point of the 3-month intervention, patients in the MCCR group did not experience a change in their HbA1c levels from baseline, however the patients in the LCK group observed a significant 0.6% reduction in HbA1c compared with the patients in the MCCR group (-0.6%, 95% CI, -1.1% to -0.03%, p=0.04). Results also showed that the 44% of the LCK group reduced the need for anti-glycaemic medication compared with 11% in the MCCR group (p=0.03). However, it is important to note that LCK group lost more weight that the MCCR group, although the between-group difference was not statistically significant (5.5 kg vs. 2.6 kg, p=0.09). The greater weight loss in the LCK diet group, although not statistically significant, may have led to the greater reduction in HbA1c observed. Furthermore, this study included behavioural change therapy to help participants make dietary changes, which may have been a confounding factor impacting dietary adherence. This study is also limited due to the absence of isocaloric content in the prescribed diets. Therefore it makes it problematic to appreciate how much of a role weight loss had in achieving the differences in the measured outcomes compared with the effect of the macronutrient composition of the diets (Saslow et al. 2014).

Tay et al. examined the effects of a very low-carbohydrate, high-unsaturated/ low-saturated fat diet (LC) (14% carbohydrate, 17% protein, 30% fat) with a high-unrefined carbohydrate, low-fat diet (HC) (53% carbohydrate, 17% protein, 30% fat) on glycaemic control in obese participants with T2DM (Tay et al. 2014). Both diets were designed to be hypocaloric and energy-matched. Authors reported similar completion rates for both diets (LC 79%, HC 82%). By the end of the 24-week intervention, there were no significant differences in weight loss between two groups (LC -12.0 ± 6.3 kg, HC -11.5 ± 5.5 kg p =0.50). However the LC diet reduced HbA1c more than the HC diet -2.6 % ± 1.0% vs. -1.9 ± 1.2% p=0.002. Self-assessed energy intakes did not differ between groups, and accelerometry data showed that activity count and time spent in moderate to vigorous activity increased similarly between the diets (p=0.51). This is reflective in the non-significant difference in weight loss observed, as both energy intake and PA were not different between the groups. The strength of this study was that the prescribed isocaloric diets were successfully maintained throughout the intervention. Therefore it is more reasonable to assume that the differences observed in the reductions in HbA1c can be attributed to the differences in the composition of the diets. However, as this study included a structured physical activity programme, it would be reasonable to expect any reductions in HbA1c to be the result of the combined effect of both the dietary and physical activity interventions, and not merely the result of the prescribed diets.

2.2.2.3 Systematic reviews/ Meta-analysis

In 2009 Kodama and colleagues conducted a meta-analysis looking at the effects of low fat, high carbohydrate (LFHC) and high fat, low carbohydrate (HFLC) diets on glycaemic control in participants with T2DM, with 19 studies consisting of 306 patients included in the analysis.

Alterations in fasting plasma glucose and HbA1c did not show any significant differences between the two groups. However the LFHC diet significantly reduced HDL cholesterol by 6% ($p<0.001$), and increased both fasting insulin and triglycerides by 8% ($p=0.02$) and 13%, respectively ($p<0.001$). Authors concluded that HFLC diets could be effective in improving glycaemic control without negatively impacting blood lipids (Kodama et al. 2009)

2.2.3 Diets with varying glycaemic index/ glycaemic load:

This section provides an overview of the studies examining the effects of diets with differing levels of glycaemic index/glycaemic load on T2DM prevention and treatment.

2.2.3.1 Observation studies

The glycaemic index (GI) is a measure of the glucose response produced in the blood stream post-consumption of a particular food source when compared to a reference food (glucose solution or white bread) (Venn & Green 2007). Glycaemic load (GL) is calculated by multiplying the GI of a food by the total carbohydrate content in the sample (Salmeron et al. 1997). There is an on-going debate around the usefulness of applying GI and GL in the dietary management of T2DM.

In 2004 Hodge et al. tested the relationship between glycaemic index (GI), glycaemic load (GL) and T2DM. This prospective study consisted of 36, 797 men and women aged between 40-69 years old who did not have T2DM. A total of 31, 641 of the initial participants took part in the 4-year follow-up, with results showing that dietary GI (OR per 10 units 1.32, 105-

1.66) was positively associated with T2DM. Another prospective study, this time examining data from the 8- year follow-up from the Black Women's Health Study, revealed a positive association between GI and the risk of developing T2DM (Incidence Rate Ratio 1.23, 95% CI, 1.05-1.44) (Krishnan et al. 2007).

In contrast to this study, Simila and colleagues examined the association between dietary GI with T2DM in a cohort of Finish men (Simila et al. 2011). This study indicated that glycaemic index and glycaemic load were not associated with the risk of developing T2DM, with multivariate relative risk (RR) for highest v. lowest quintile for GI being 0·87 (95 % CI 0·71, 1·07) and for GL 0·88 (95 % CI 0·65, 1·17). Authors did, however, report that substituting medium GI carbohydrates for higher GI carbohydrates had an inverse relationship with T2DM risk, however replacing higher GI carbohydrates with low GI carbohydrate sources was not associated with a lowering risk of T2DM development (Simila et al. 2011).

2.2.3.2 Randomised controlled trials

In 2004, Rizkalla et al. reported the results of a randomised controlled trial involving 12 men with T2DM, who were randomly assigned to two periods of either a high GI or low GI diet, in a crossover study design, with a 4-week washout period between the diets. Results showed that the 4 weeks on the low GI diet improved HbA1c ($p<0.01$) and fasting plasma glucose ($p<0.01$). This trial demonstrated a benefit of a low GI diet on improving glycaemic control in men with T2DM. Analysis of 7-day food diaries showed similarities in total energy intake and macronutrients between the two diets. Nevertheless, there was a significantly higher fibre intake in the low-GI diet. This is of importance as fibre itself plays a role in glycaemic control (Post et al. 2012).

Similarly, Wolever and associates studied the effects of changing the glycaemic index of diet on plasma glucose, HbA1c and C-reactive protein, in participants with T2DM. (Wolever et al. 2008). The 162 participants in the study were randomly assigned to a high GI, low GI or a low carbohydrate diet for the period of 1-year. After the 1-year intervention, HbA1c and body weight did not change significantly between the diet groups. After 12 months, 2-hour post-load glucose was lower (p=0.010) in the low GI diet, but fasting glucose was higher (p=0.041). Average C-reactive protein in the low GI diet was 1.95mg/L, which was 30% less than that in the high GI group. Authors concluded that the study revealed that altering GI did not affect long-term HbA1c. The mean HbA1c of the participants at baseline was 6.1%, compared to the trial ran by Rizkall et al. where mean baseline HbA1c was 7.5%. It is unclear whether a patient's initial HbA1c levels are relevant in regards to their responsiveness to a change in dietary GI.

In 2008 Ma and colleagues compared the American Diabetes Association (ADA) diet to a low-GI diet in a sample of 40 patients with T2DM. This study had a comprehensive educational design where 8 educational classes were provided, which included group work in food preparation in a study kitchen to help participants learn how to make better choices when eating out. Along with the group sessions, patients also had individual sessions with the dietitian where any problems or concerns regarding their specified diets were addressed. At the end of the 12-month intervention both patients in the ADA and the low-GI group had similar mean HbA1c levels (p=0.08), along with no statistically significant difference in weight loss (p=0.31). However, those on the low-GI diet were found to need less diabetic medication (OR 0.26, p=0.01). Although the low-GI diet was shown to be more effective in reducing the need for medication, neither diet was superior in reducing HbA1c levels. A limitation of this study was the differential adherence rates between the two groups, with adherence lower in the low-GI group. Furthermore the mean age was significantly higher in the low-GI group (51.0 vs. 56.31, p<0.05), which could have been a confounding factor.

2.2.3.3 Systematic reviews/ Meta-analysis

In 2003 a meta-analysis of 14 studies consisting of 356 participants was conducted, with all studies included being either randomised crossover or parallel studies. Brand-Miller and colleagues concluded that low-GI diets reduced HbA1c by 0.43% points (CI 0.72-0.13) more than that produced by high-GI diets. The study demonstrated a small but clinically significant benefit in choosing low-GI foods over high foods for glycaemic management in people with T2DM (Brand-Miller et al. 2003).

A Cochrane systematic review was conducted in 2009 by Thomas & Elliot. Eleven randomised controlled trials met their inclusion criteria, which included a total of 402 participants. The trials included lasted between 1 to 12 months, with results showing a 0.5% decrease in HbA1c for low GI diets, which was both statistically and clinically significant (Thomas & Elliot 2009)

Both systematic reviews demonstrated a clinically significant effect of low-GI diets. An issue with using the GI arises when discussing mixed meals. GI values published in tables represent glucose responses in fasted participants taking that particular food source in isolation. Some researchers have commented that once different food sources are mixed in a meal, the GI of the total content of the meal will be different from the combined tabulated values. Sugiyama et al. demonstrated that the mixture of carbohydrate foods along with dairy, vinegar and bean products significantly reduced the GI of white rice (Sugiyama et al. 2003). Flint et al. looked at predicting GI in composite breakfast using table values, reporting no relationship between the predicted GI and that, which was measured. Multivariate analysis showed that the GI of a meal was best predicted by the fat and protein content (Flint et al. 2004).

2.2.4 Mediterranean diet:

This section provides an overview of the evidence examining the effects of the Mediterranean diet on the prevention and treatment of T2DM.

2.2.4.1 Observation studies

The Mediterranean diet typically consists of relatively high intakes of unrefined grains, vegetables, fruit, and legumes along with moderate amounts of dairy. Olive oil is the primary oil used for cooking, with fish and poultry being consumed in moderate to high quantities, while red meat consumption is relatively low. Alcohol is also consumed in moderation mainly with meals (Tortosa et al. 2007). Other characteristics of the diet include low intakes of trans fatty acids, high fibre intake, and higher intake of vegetable fat (Martinez-Gonzalez et al. 2008).

Epidemiological studies have shown reduced morbidity and increased longevity in Mediterranean countries when compared with Northern Europe and the United States (US) (Keys et al. 1986). Mediterranean diets have furthermore been shown to improve insulin sensitivity (Ciccarone et al. 2003).

A Spanish cohort study following 13,380 university graduates for an average of 4.4 years, investigated the relationship between Mediterranean diet adherence and T2DM (Martinez-Gonzalez et al. 2008). Dietary habits were assessed at baseline using a food frequency questionnaire (FFQ), which was scored on a 9-point index. Results showed that close adherence to the diet reduced the risk of developing T2DM; incidence ratios were 0.17 (95% CI 0.04 TO 0.75) for those with the greatest adherence (scored 7-9 on FFQ) compared to 0.41 (95% CI 0.19-0.87) for those with moderate adherence (Score 3-6) relative to those with the lowest adherence (score <3).

More recently a meta-analysis by Koloverou et al. 2014 including data from 10 prospective studies and 136,846 participants, revealed that participants who had a higher adherence to a Mediterranean diet had 23% reduced risk of developing T2DM (combined relative risk for upper versus lowest available centile: 0.77; 95% CI: 0.66, 0.89) (Koloverou et al. 2014).

Koloverou and colleagues (2014) further examined the risk of developing T2MD in 1514 individuals during a 10-year follow-up period. Adherence to a Mediterranean diet was assessed using a validated questionnaire, which included both dietary factors and lifestyle choices. After 10 years, 12.9% (13.4% men and 12.4% women) of the participants developed T2DM. Both a medium and a high adherence to a Mediterranean diet was reported to reduce the risk of developing T2DM by 49% (95% CI: 0.30, 0.88) and 62% (95% CI: 0.16, 0.88), respectively, when compared with those who reported low adherence to the diet. The inflammatory cytokines TNF-alpha and IL-6 levels were significantly lower in the individuals who had a higher adherence to the Mediterranean diet (4.8 ± 4.8 pg/mL and 1.3 ± 0.40 pg/mL, $p<0.001$) compared to those with low adherence, (8.2 +/- 3.9 pg/mL and 1.6 +/- 0.48 pg/mL). The role of the Mediterranean diet in influencing TNF-alpha and IL-6 levels reveals possible mechanisms by which diet could help reduce T2DM development, with previous data highlighting the roles of high circulating levels of these inflammatory cytokines in the development of insulin resistance (Bach et al. 2013).

2.2.4.2 Randomised controlled trials

Esposito and colleagues (2009) reported the results of a randomised control trial comparing the effects of a low-carbohydrate Mediterranean-style diet to a low-fat diet on the need for anti-hyperglycaemic drugs in newly diagnosed T2DM patients. This trial lasted 4 years, with 108 overweight participants randomised to a Mediterranean-style diet whereby <50% of their total calories came from carbohydrate, with the other 107 participants randomised to a low-fat diet in which <30% of their calories came from dietary fat. Participants were deemed to need antihyperglycaemic medication when HbA1c follow up recorded a measurement of > 7%. At the end of the intervention, 44% of participants on the Mediterranean diet necessitated treatment compared with 70% of those in the low-fat diet group, hazard ratio 0.70 [CI, 0.59 to 0.90] $p<0.001$, when adjusted for weight change. The trial showed greater improvements in glycaemic control and weight loss in the participants on the Mediterranean diet. Both intervention groups were set energy intake targets of 1,500 kcal/d for women and 1,800 kcal/d for men. However participants in the Mediterranean diet lost more weight, with the absolute between-group difference in weight loss being -2.0 kg [CI, -3.0 to -0.9kg]. As dietary intake was self-reported, this does raise the possibility that adherence may have been greater in the Mediterranean group, as apparent in the greater weight loss seen in the group. The major strength of this study was that participants were newly diagnosed with T2DM and so were not on any anti-glycaemic medication at the beginning of the intervention. Therefore any changes due to the dietary intervention were not impacted by medication use. The study demonstrated a potential use of a Mediterranean-style diet for improving glycaemic control in overweight patients with T2DM.

Cerriello et al. 2014 conducted a 3-month intervention comparing a Mediterranean diet using olive oil to a low-fat control diet. Twelve participants with T2DM were included in each group. Along with various measurements, the effect of glucagon-like peptide-1 (GLP-1) during a hyperglycaemic clamp was measured at baseline and at the end of the 3-month intervention. Results showed that the Mediterranean diet increased GLP-1 induced insulin secretion, with authors concluding that a Mediterranean diet improves the action of GLP-1 in patients with T2DM. Therefore a possible mechanism in which the Mediterranean diet may work to improve diabetes management may be through its positive effects on GLP-1 (Cerriello et al. 2014).

There have been data supporting the role of glucagon-like peptide-1 (GLP-1) analogues in the management of T2DM (Peters 2010). GLP-1 appears to play key roles in protecting against impaired beta cell function while reducing glucagon secretion, both of which can have beneficial effects on glycaemia (Peters 2010), with GLP-1 resistance seen in patients with poor glycaemic control (Herzberg-Schafer et al. 2012). Possible mechanisms for this occurring is the activation of PKC-beta, which can be induced by hyperglycaemia which in turn can reduce the expression of GLP-1 receptors (Mima et al. 2012). It has been hypothesised that oxidative stress produced through hyperglycaemia is seen as a mechanism for initiating the GLP-1 resistance in these patients (Corriello et al. 2011), with in vivo experiments demonstrating the use of antioxidants such as vitamin C in improving GLP-1 resistance (Corriello et al. 2013).

2.2.4.3 Systematic reviews/ Meta-analysis

In a recent systematic review, Ajala et al. (2013) investigated the effects of different diets on improving glycaemic control and weight loss. These researchers conducted online searches reviewing data from August 2011 onwards. They used the specific criteria outlined in the Cochrane Handbook to assess the quality of the trials. Only randomized-controlled trials lasting for 6 months or more were considered. Twenty RCTs met the inclusion criteria, totalling 3073 participants. Results of the meta-analysis showed that Mediterranean, low carbohydrate, low-GI and low protein diets produced greater improvements in HbA1c when compared with their respective controls. Ajala et al. concluded that the Mediterranean diet had the largest effect size. Analysis also showed that both the Mediterranean and low carbohydrate diets produced the greatest weight loss (-1.84kg and -0.69kg, respectively). However, only the Mediterranean diet was shown to be more effective in terms of weight loss when compared with its control. Both low carbohydrate and low-GI diets did not show any significant differences in weight loss when compared with their respective controls.

These findings are in contrast to the findings from a systematic review conducted by Wheeler et al. in 2010. These authors also examined the effects of the Mediterranean diet and concluded that there was no advantage in this type of diet compared with others for improving glycaemic control. With regards to Mediterranean diet, Wheeler et al. only included 5 RCT's and the studies examined were from January 2001 to October 2010. When the interventions covered in this systematic review are viewed in more detail, certain limitations become apparent. One issue is the lack of a universal definition of what constitutes a 'low carbohydrate' diet. In the trials included, low carbohydrate diets ranged from <20 grams/day to diets comprised of 15-45% of total energy consumption. This leads to a wide range of carbohydrate intakes, which were all grouped into the low carbohydrate category when this analysis was conducted.

In an editorial, Mann and Morenga (2013) re-calculated the data from Ajala et al. comparing low carbohydrate diets with the use of a random-effect model. Their results showed a more marginal effect of low carbohydrate diets than that initially stated by Ajala et al. 2013 (effect size: -0.28; 95% Cl: -0.56, 0.00 p=0.05).

2.2.5 Influence of energy content of the diet:

This section provides an overview of the evidence examining the effects of the energy content of diets on the prevention and treatment of T2DM.

2.2.5.1 Observation studies

A net positive energy balance, resulting in a disordered storage and mobilisation of adipose tissue is considered a pivotal factor in the pathogenesis of T2DM (Lewis et al. 2002), with correlation studies showing that 80-95% of patients with T2DM are either overweight or obese (Horton et al. 2010). As such, practices to reduce weight are believed to be crucial for treating patients with T2DM (Franz et al. 1994). Studies have demonstrated that even a modest reduction of ~5% body weight has been associated with favourable changes in glycaemic control (Barrett-Connor 1989). A prospective analysis study of 4,970 overweight individuals with T2DM looked at the relationship between weight loss and health outcomes. After adjusting for various factors, intentional weight loss was associated with a 25% reduction in total mortality (RR= 0.72; 0.63- 0.82). Furthermore, deliberate weight loss of between 20 to 29 lbs, was linked with a 33% reduction in mortality (Williamson et al. 2000).

Kang and Kim (2012) demonstrated that high total energy consumption was associated with poor glycaemic control. In this study, 334 individuals with diabetes who partook in the 2005 Korean National Health and Nutrition Examination Survey were assessed. HbA1c was recorded for all, and dietary intake was determined by 24-h dietary recall. Results showed that higher energy intakes were associated with higher HbA1c levels in the participants. Interestingly, individual macronutrients were not associated with HbA1c levels.

2.2.5.2 Randomised controlled trials

Williams and colleagues (1998) conducted a 20-week intervention trial on 54 overweight individuals with T2DM. Participants were randomised to either one of two very-low-calorie-diet (VLCD) groups or to a standard behavioural therapy (SBT) group. SBT group were prescribed a 1500-1800 kcal/d diet for the 20-week period. Participants in the VLCD groups followed the VLCD for 5 consecutive days during the second week of the intervention. This was followed by either ‘intermittent VLCD therapy’ for 1 day/week for a period 15 weeks, or for 5 successive days every 5 weeks, with individuals consuming a 1,500-1,800 kcal diet during days when not on the VLCD. Results showed that periodic VLCDs enhanced weight loss in participants with T2DM. Both VLCD groups showed reductions in fasting plasma glucose as compared in those in the SBT group after 3 weeks. Fasting plasma glucose decreased by 2.3 ± 1.5 mmol/l in the 5-day group compared to a decrease of 2.2 ± 2.3 mmol/l in the 1-day group, in contrast fasting plasma glucose decreased by only 0.8 ± 0.9 mmol/l in the SBT group, however, changes in fasting plasma glucose did not reach statistical significance in any of the groups.

More recently Stevens et al. (2016) conducted a study examining 8 weeks of VLCD (600-700 kcals/day) followed by an isocaloric diet for 6 months on 30 adults with T2DM. Authors reported that 12 of the 30 participants managed to achieve a fasting glucose level of less than 7mmol/L after transitioning to the isocaloric diet; these participants were referred to as ‘responders’. HbA1c levels decreased in the responders from 7.1 ± 0.3 to 5.8 ± 0.2%, $p < 0.001$. This study again demonstrates the possible use of VLCD in treating T2DM, although due to the lack of responsiveness of certain participants, it may not be effective for everyone.

It is important to note that this was a small non-randomized trial and it yet remains to be seen whether this sort of dietary intervention will be suitable for use with the general population due to the problems associated with adherence to VLCDs (Stevens et al. 2016).

2.2.5.3 Systematic reviews/meta-analysis

Anderson and colleagues (2003) undertook a meta-analysis of the consequences of weight loss on obese patients with T2DM. In this meta-analysis, controlled clinical trials assessing changes in lifestyle on the risk of developing T2DM, along with the effects of weight loss on cardiovascular risk factors and glycaemic control were reviewed. Initially, the authors conducted a systematic review focusing on the use of Very Low Energy Diets (VLED) typically below 1000 kcal/day. Nine studies were examined including a total of 192 obese participants, with interventions lasting between 4-6 weeks. Over the course of 6 weeks, participants lost an average 9.6% of pre-intervention body weight along with experiencing a 50% decrease in fasting plasma glucose within the first 2 weeks. By the end of the interventions, fasting plasma glucose levels were at less than half of the pre-intervention values.

The second part of this review looked at the effects of Low Energy Diets (LED) typically consisting of 800-1200 kcal/day for a longer duration of 48 weeks. In this analysis, the pooled studies included 376 obese participants with T2DM. Results showed that participants lost 14.7% of initial body weight over the initial 16 weeks while supervised. Over the course of the next 32 weeks, the participants regained an average of 3kg. During the first 16 weeks, fasting plasma glucose levels decreased by 30.5% from baseline, with levels slowly increasing during the last 32 weeks as body weight increased. The findings from this systematic review demonstrate the importance of reducing total energy intake in the management of glycaemic control in obese participants with T2DM.

2.2.6 Conclusions

Given the trends in the increased incidence of T2DM, it is imperative to be able to design effective dietary interventions. As demonstrated by the studies discussed in this literature review, various forms of diets consisting of a range of macronutrient profiles have been examined. Some have shown slightly greater improvements, including 'Mediterranean', 'Vegan', and 'High Fibre' types.

Although the data indicate that certain diet types may be more effective than others, it is important to critically evaluate the methodologies used. The reliance on self-reported data along with the lack of standardisation of energy intake raises questions as to the true origins of the glycaemic improvements observed. Furthermore underreporting of energy intake is a major limitation when using nutrition questionnaires (Gemming et al. 2013), however self-reported dietary intake still represents an economical method for collecting valuable information about food consumption, which can be used to inform nutritional policy. Nonetheless its limitations must be acknowledged when analysing data and interpreting the results (Subar et al. 2015). In order to state that a certain diet is superior to another as an intervention for people with T2DM, they ideally should be equal in energy content for both intervention and control groups. Hence any improvements then seen can be attributed to the macronutrient profile of the diet and not due to lower energy content.

Studies have shown benefits of moderate amounts of exercise in improving glucose metabolism in the absence of weight loss (Duncan et al. 2003), but data showing any improvements in glycaemic control in people with T2DM through diet alone without weight loss is limited. However, the current data provide overwhelming support for the role of weight loss in improving glycaemic control. Therefore, there is a need to systematically examine the existing literature to determine whether certain diets do in fact result in a more favourable glycaemic control independent of the effects of weight loss. Conducting a systematic review in this area will help us to gain a better understanding of the degree of influence of weight loss versus macronutrient composition of the diet on glycaemic control, which in turn will enable the design of effective dietary interventions for the emerging number of patients with T2DM.

2.3. Type 2 Diabetes and diet in South Asian populations

This section provides an overview of the prevalence and pathogenesis of T2DM in South Asia, as well as exploring the dietary intake characteristics of this population.

2.3.1 South Asians in the UK

In the UK South Asian are the second largest ethnic minority group in the UK after the white British population (Census 2011). They represent 4.9% of the total population (Indian 2.3%; Pakistan 1.9%; Bangladesh 0.7%), accounting for over 3 million people (Census 2011).

As illustrated by the census data, there is a large degree of heterogeneity with the South Asian population. Although the term 'South Asian' is commonly used when conducting research in this population, it is important to understand that the term encompasses a wide variety of people, many of which speak different languages, have different faiths and come from a wide range of diverse cultures. These background characteristics will ultimately impact their lifestyle behaviours differently. Therefore although in terms of conducting research grouping these populations as one may be useful, we must appreciate that we are not discussing a homogenous population, and as such the cultural needs of the people within the population may not be the same.

2.3.2 Prevalence of Type 2 Diabetes in South Asian populations

In 2011, Danaei et al. conducted a meta-analysis including data from 199 countries, with the results indicating that between 1980 and 2008 the prevalence of T2DM has increased globally, with South Asia and the Middle East/ North Africa being amongst the areas where prevalence was particularly high (Danaei et al. 2011). South Asia is now considered to be a global hotspot for T2DM, with the International Diabetes Federation (IDF) estimating that over 70 million people in the area have T2DM (IDF 2011). Given that over 76% of the people in South Asia live in India, much of the research into the prevalence of diabetes in the area focuses on India (UN 2015). Initially data in the 1970s suggested that the prevalence of diabetes in India varied depending on location, with 1% in rural areas and 2% in urban areas (Ahuja 1979), but in 2011 data collected by Anjana et al. (2011) indicated that 10% of people living in rural areas and 20% of people living in urban areas now have T2DM. With T2DM rates in India increasing dramatically, it is of critical importance to understand the causes behind the recent increases in T2DM from these geographic regions of the world (Anjana et al. 2011). Major contributory factors explored in these final two sections of the literature review will be genetics, diet, physical activity, and time spent being sedentary.

2.3.3 Pathogenesis of Type 2 Diabetes in South Asians

Please note that the following sections of this chapter will explore the differences in both the pathogenesis and anthropometrics between South Asian and ‘Caucasian’ populations. The term ‘Caucasian’ is what is commonly used in the literature to denote a person as being ‘white’ and hence why it has been employed in some of the studies referenced in this chapter.

Johan Friedrich Blumenback, a German physician, proposed the term ‘Caucasian’ in his thesis in 1795, in relation to what he believed was one of the five generic varieties of humans (Bhopal 2007). Blumenbachs’ work involved distinguishing differences in race not by the colour of a populations’ skin, but by the shape of their skulls. He had the highly controversial viewpoint that a white persons skull was more ‘beautiful’ than that of others, and proposed that the most ‘beautiful’ people were from the southern slope of Mount Caucasus in Georgia, hence the term ‘Caucasians’ (Bhopal 2007). The racist contentions associated with this terminology means that its future use in research literature should be discouraged.

When examining the pathogenesis of T2DM, there are two common explanations for the underlying cause of the condition. Some studies have supported the idea of an adipose-induced insulin resistance, which over time leads to a gradual decrease in beta-cell function (Kahn et al. 2003, Saad et al. 1991), with others highlighting an initial reduction in beta-cells as the reason for predisposing individuals to developing T2DM (Cnop et al. 2007).

In 2013, Bhopal introduced a ‘4-stage model’ to explain the high prevalence of T2DM in South Asian populations over the course of the lifespan (see Figure 2.2):

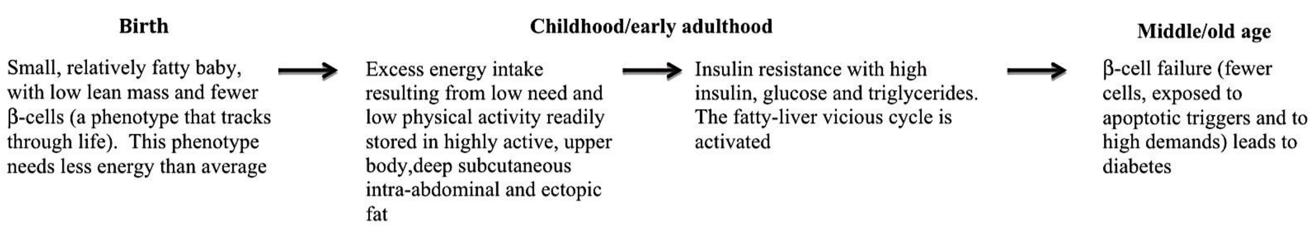

Figure 2.2 Representation of the four-stage model for explaining why T2DM is more prevalent in South Asians compared to ‘Caucasians’ (Bhopal 2013).

1) Birth and Early life:

South Asian babies have a lower birth weight compared with ‘Caucasian’ babies, in addition to having less muscle mass and a greater body fat percentage (Yajnik et al. 2002). A consequence of having a low birth weight (LBW) baby is a lower than normal number of beta-cells in the pancreas (Meier 2009). A decreased number of beta-cells is not in itself a problem, as the mechanisms in place may be evolutionarily advantageous for survival, as it will benefit a low energy environment by allowing the baby to have reduced energy expenditure, hence becoming more efficient at storing energy. However if the baby’s environment changes during adulthood, this could create an imbalance, which may lead to metabolic disorders (Bhopal 2013).

2) Childhood and 3) early adulthood:

These LBW babies then go on to become children possessing relatively high amounts of subcutaneous truncal fat (Nightingale et al 2011). By the time they reach young adulthood, changes in adipocytes become apparent. Anand et al. 2011 compared adipocytes in 108 healthy South Asian and ‘Caucasians’, with an average age of 36.8 yrs. and 34.2 yrs., respectively, reporting that total adipocyte area was increased in South Asians compared to ‘Caucasians’ (mean difference: 64.26; 95% CI: 24.3 to 104.1 units^2) (Anand et al. 2011).

South Asians also have lower amounts of skeletal muscle mass when compared with ‘Caucasians’ (Rush et al. 2009). Hall et al. (2010) demonstrated differences in insulin resistance in the skeletal muscle of South Asians. In this study, South Asians and ‘Caucasians’ were asked to take part in exercise and metabolic testing, with muscle biopsies being taken to determine insulin-signalling proteins. Results showed a 26% reduced insulin sensitivity in South Asians compared with 'Caucasians' (p=0.010) (Hall et al. 2010).

Adipose tissue storage is also an issue in South Asians. When an individual is in an energy surplus, excess energy is usually deposited in superficial subcutaneous adipose tissue, in particular in the lower limbs where fat deposition is not regarded as problematic in relation to metabolic disorders (Sniderman et al. 2007). However, South Asians tend to store a greater amount excess energy in deep subcutaneous tissue and in the truncal region, which are understood to be areas of the body involved in the pathogenesis of insulin resistance (Misra & Vikram 2003).

4) Middle/Old age:

As the young adult enters middle and old age, the insulin resistance in the skeletal muscle results in more glucose being transported to the liver, where it is deposited as fat tissue. This increased deposition of fat increases hepatic insulin resistance and hence triggers the 'fatty-liver vicious cycle' (Taylor 2008), leading to an increase in endogenous glucose production leading to hyperglycaemia (Bhopal 2013).

2.3.4 Role of genetics/epigenetics in development of Type 2 Diabetes

In 1962, Neel first proposed the 'thrifty genotype hypothesis' suggesting that as a result of enduring periods of famine, some populations have acquired 'thrifty genes' (Neel 1962). In turn, these genes result in the form of metabolic programming permitting the individuals to become efficient at storing energy compared to other populations who do not possess the genes. The concern arises when individuals with a ‘thrifty phenotype’ are exposed to a nutritional environment that offers excess energy intake and inadequate physical activity. In these circumstances, these individuals will be at an increased risk of gaining weight and developing a host of metabolic disorders including T2DM (Neel 1962).

The term “epigenetics” refers to the heritable modification of gene activity without the alteration of DNA sequence (Ambady et al. 2013). The in utero nutritional environment can affect the metabolism and adiposity of the offspring, through epigenetic changes resulting in altered metabolic phenotype (Pollin 2011). This has been demonstrated in rat models, in which pregnant rats prescribed a reduced protein diet, led to having obese offspring (Lillycrop et al. 2005). Epidemiological data in humans also supports the importance of maternal nutrition in determining the offspring’s metabolic phenotype. In 1976, Ravelli and colleagues studied children who were born during the Dutch famine (Ravelli et al. 1976). The study included a cohort of 300,000 young men who were exposed to famine while in utero. Authors concluded that exposure to famine during the first half of pregnancy resulted in significantly higher obesity rates.

2.3.5 Anthropometric differences between South Asians and Caucasians

South Asian populations develop T2DM at a younger age compared with ‘Caucasian’ populations (Chiu 2011). A BMI of 30 kg/m^2 or more has been used to classify obesity, which in turn relates to increased risk of a variety of diseases, including T2DM, and has been validated in white populations (Flegal et al. 2004). However, the applicability of the BMI cut-off values for other ethnic populations is unclear and controversial.

In 2011, Chiu et al. (2011) conducted a multi-ethnic cohort study including 59, 824 non-diabetic adults. Participants were followed up for a maximum of 12.8 years to detect the onset of T2DM. After adjusting for confounding factors (age, sex, BMI and socio-demographic factors), authors reported that the risk of T2DM was significantly higher in black, Chinese and South Asians participants relative to white 'Caucasians', with South Asians having the greatest risk of developing the disease (hazard ratio 1.87, P = 0.002). When determining the BMI cut point where incidence rates were the same as a BMI of 30kg/m^2 in white populations, it was calculated to be 24 kg/m^2 for South Asian participants. Results also showed that South Asian participants developed the disease at a significantly younger age than the white participants. This cohort study provided evidence for a need to re-evaluate BMI cut points for classifying disease risk in different ethnic populations. The World Health Organization (WHO) has suggested that a cut point of a BMI below 23.0 kg/m^2 for use in South Asian populations (WHO 2004).

Abdominal obesity is highly prevalent in South Asians and is also seen at much younger ages when compared with 'Caucasian' populations (Misra 2003). In 2007, Chandalia et al. (2007) compared body fat distribution and insulin resistance between South Asian and Caucasian men, with results illustrating that even at similar body fat levels, South Asians had waist circumference measurements, which were 10 cm less than that for 'Caucasians' (Chandalia et al. 2007). Similar to the rationale for revising BMI cut-off points for South Asians, the same has been done for waist circumference measurements. In 2006, the IDF set a cut point of >/ 90 cm for South Asian males and >/ 80 cm for South Asian females. This was a reduction from the original general cut point of >/102 cm for males and >/ 88 cm for females (Alberti et al. 2006).

Yanjik and colleagues (2002) compared birth weight and insulin concentrations between newborn babies in India (n = 157) and 'Caucasian' babies in the UK (n = 67). The mean birth weight for Indian babies was significantly lower compared with the Caucasian babies (2805g vs. 3475g respectively, $p < 0.001$). Cord blood samples were used to compare insulin levels, and after adjusting for birth weight, results showed that insulin levels were higher in the Indian babies (Yanjik et al. 2002). This study established the existence of hyperinsulinaemia at birth in this population of Indian babies, which is in itself a risk factor for developing T2DM later in life.

2.3.6 Dietary patterns in South Asian populations

South Asian populations are now prevalent in many countries around the world. In the UK they represent 4.9% of the total population, which equates to approximately 3,080,000 people, representing the largest ethnic minority group in the country (UK Census 2011). The main South Asian groups living in the UK include Indian 2.3%, Pakistani 1.9% and Bangladeshi 0.7%.

Longitudinal studies have shown changes in the diet of South Asians when they migrate to Western countries, moving away from their traditional diets and adopting a more 'Westernised' diet (Simmons and Williams 1997). Traditional diets commonly focus on carbohydrate staples of rice, roti, paratha and chapattis served with a vegetable or meat curry

(Carlson et al. 1984). This traditional diet of curries and cereals, along with high intakes of fruits and vegetables, results in a diet that is moderate-to-low in fats and high in dietary fibre (Wyke & Landman 1997).

As South Asian migrants continue to live in western countries, they often adapt to the 'Westernised' lifestyle, with new dietary habits being often adopted in place of past traditional practices (Satia-About et al. 2002). With South Asians being at an increased risk of developing T2DM, these shifts in dietary habits can have significant health consequences for South Asian immigrants (Abate & Chandalia 2001).

A study by Wandel et al. (2008) examined changes in food habits amongst South Asian immigrants living in Oslo, Norway. Using self-reported data, participants often reported increased consumption of potatoes, milk, meat, margarine and butter, with decreased intake of beans and lentils compared to when they were living in South Asia. Investigators also discovered that the more integrated the participants were with Norwegian society, the more likely they were to consume a diet containing high-fat foods (Wandel et al. 2008).

Yagalla and colleagues (1996) examined the dietary intakes of Asian Indians who were living in the United States. Using semi-quantitative food frequency questionnaires, dietary intake was measured in 153 adults. Results showed an average dietary fat consumption of 32% of total energy consumption, along with a saturated fat intake of 8% of total energy consumption. In contrast, Mistra et al. found an average total fat intake of 24-27% and an average saturated fat intake of 6.5% in a population of adults living in a slum in New Delhi, India (Misra et al. 2001). Another study reported a mean saturated fat intake of 9.4%, this time in a population of adolescents and young adults living in an urban city India (Isharwal et al. 2008). As demonstrated by these studies there appears to be a lower average saturated fat intakes in rural areas, where populations tend to adhere to more traditional diets compared with either people living in urban areas who have access to more ‘westernised’ food sources, or to those individuals who migrate to Western countries and adopt the dietary practices of the host country. Increased saturated fat intakes may have implications for glycaemic control; with studies emphasising its role in affecting both fasting and postprandial insulin levels (Misra et al. 2007), and decreasing saturated fat intake can reduce hyperinsulinaemia (Parker et al. 1993).

2.3.7 Globalisation- effects of adopting a western lifestyle

One of the patterns observed across South Asia has been the rise in the intake of animal products (FAO 2003), leading to a shift away from a more carbohydrate-based diet to one comprised of more protein and fats (Mendez et al. 2004). Data comparing consumption patterns in India in 2001 with those from 1979-1981 show significant changes, revealing that milk consumption increased by 50%, with the total consumption of eggs and vegetable oils doubling (Pingali & Khwaja 2004). Another consequence of globalisation has been the emergence of fast food restaurants, with the fast food industry in South Asian countries rapidly expanding (Tabassum & Rahman 2012). Data from India has identified national increases in both dietary fat and sugar intake; with more affluent groups consuming more dietary fat (32% energy) compared to lower income families (17%) (Shetty 2002). What is apparent in countries like India is that globalisation may have increased the standard of living for some, but the changes have created an environment, which is placing the population at a higher risk of developing metabolic diseases.

Globalisation has allowed for the integration of different cultures, and in the case of South Asia, it has introduced a more 'western' style of living. Both industrialisation and globalisation have led to a worldwide shift in the nutritional practices of populations. Even though this was initially observed in more high-income countries, it has now spread to the developing world, first in urban cities and more recently into rural communities (Popkin 2009). The net effect of this progression has been a greater availability of processed, energy-dense food. Increased consumption of high-energy foods, along with decreased physical activity is likely to lead to a positive energy balance, promoting weight gain (Malik et al. 2013). Increased consumption of these foods has been at the expense of consumption of whole-grains and legumes (Misra et al. 2009). This decrease in fibre rich foods can be seen as an important factor in the 'westernisation' of dietary intake and is an important dietary change in relation to an increase risk of obesity (Hu et al. 2010) and T2DM (Post et al. 2012).

2.3.8 Conclusion

As highlighted in this chapter, South Asians living in the UK are a high-risk group for developing T2DM. Furthermore the number and scope of papers reporting on the dietary practices of this population is limited. Due to the scale of the problem within the large number residing in the UK, it is important to understand how to design effective interventions to help reduce the prevalence of T2DM in these populations. South Asia is a vast area encompassing many countries, with each country having its own dietary practices, religions, and languages.

To be able to design effective community-based interventions, it is important to consider current dietary practices and eating behaviours to ensure interventions are culturally tailored to meet the needs of the target audience (Ambady 2013). To date, very little is known about food intake and dietary patterns of South Asian men living in the UK. As these individuals are at high risk for T2DM, there is a need to examine these factors in this population to inform the development of diabetes prevention interventions that are culturally sensitive and appropriate.

2.4. Physical activity, sedentary time and Type 2 Diabetes,

This section will provide an overview of the role of physical activity (PA) and sedentary time (ST) in the prevention and treatment of T2DM, as well as exploring the current research assessing these behaviours in South Asians.

2.4.1 Physical activity/Sedentary time

Current guidelines recommend that adults aged between 18-64 years should perform at least 150 minutes of moderate intensity PA or 75 minutes of vigorous intensity activity a week in order to promote general health and well-being (WHO 2010a; UK Department of Health 2011). Also, it is now recognised that sedentary behaviour is an independent risk factor for numerous health outcomes in adults (Thorp et al. 2011). Sedentary behaviour is defined as any waking activity measured at less than or equal to 1.5 metabolic equivalents (METs), while an individual is in a sitting or reclining posture. However, sedentary behaviour is not to be mistaken for physical inactivity, which in itself is defined as having activity levels below the minimum recommendations (Sedentary Behavior Research 2012). Although there are currently no guidelines for time spent being sedentary, it is suggested that sedentary behaviour be reduced by breaking up periods of sedentary time with bouts of PA to promote public health (UK Department of Health 2011).

2.4.2 Measuring physical activity

Self-report has been the primary method for measuring PA for most population-based studies (Shephard & Aoyagi 2012), and for many countries, recorded trends in changes in PA are based on a long history of questionnaire-based assessment (WHO 2010b). In recent years technological advances and reductions in costs have led to an increase in objectively measured PA using accelerometers (NOO 2009).

A systematic review conducted by van Poppel and colleagues in 2010 including 85 (versions of) self-reported physical activity questionnaires concluded that for assessing PA, no questionnaire or type of questionnaire was superior (van Poppel et al. 2010). More recently Silsbury et al. conducted a similar review including only ten questionnaires (three versions of the IPAQ):

- International Physical Activity Questionnaire (IPAQ)
- The Recent Physical Activity Questionnaire
- PA Assessment Tool
- Six-Point Scale
- Human Activity Profile
- Single-Item Measure
- G-S 1 Week Recall

Authors stated that there is inconclusive evidence to suggest one questionnaire is superior to another, but concluded that because all forms of the IPAQ demonstrated very good/excellent test-retest reliability, and given that it has been researched more than any other of the self-report PA questionnaires, across a variety of populations and demographics, it is the most appropriate tool for outcome measures in both research and clinical settings (Silsbury et al. 2015).

The International Physical Activity Questionnaire (IPAQ) was first developed in 1997 and was used to measure various aspects of PA (Bauman et al. 2009), and has since been widely used around the world to measure PA subjectively. A systematic review by Lee et al. 2011 assessed the validity of the IPAQ-Short Form (IPAQ-SF), including 23 validations studies. Results showed that the correlation between total PA as measured by the IPAQ-SF and objective methods varied from 0.09 to 0.39. Given that the strength of these associations range from very weak to weak, it highlights the limitations of using self-report methods to measure PA as well as their application in health promotion. The authors of this review concluded that the IPAQ-SF overestimated PA by an average of 84%. Therefore as with all self-report tools, the IPAQ-SF is not without its limitations.

Accelerometers are comfortable to wear motion sensors, which can be used to produce data on time spent in sedentary, low, moderate and vigorous PA, in addition to providing a valid step count estimate (Esliger et al. 2007). They have been shown to be effective when used in large group studies (Babakus-Curry & Thompson 2014). Data collected can then be used to estimate time spent in moderate-to–vigorous PA (MVPA) (Spittaels et al. 2012) and compared with WHO physical activity recommendations (WHO 2010a) to determine whether individuals are meeting minimum requirements.

The main advantage of using accelerometers over traditional self-assessment questionnaires is to reduce the social desirability response bias, which is often observed with self-report methods (Janz 2006, Katzmarzyk & Tremblay 2007, Reilly et al. 2008). One limitation of accelerometers is that they cannot record activities such as swimming, bicycling, or muscle-strengthening exercises, which are also part of the WHO PA recommendations for health (WHO 2010a).

For a measure of PA to be useful, it is important for the device to be deemed acceptable by participants, to ensure adequate adherence. As a general approach to be able to assess day-to-day variability in PA and ST, participants are usually instructed to wear accelerometers during waking hours for seven consecutive days (Pedisic & Bauman 2014). The exact number of days of monitoring needed for reliable estimates of regular PA is still debated (Baranowski et al. 2008, Hart et al. 2011). Generally, valid data is defined when a participant has 10 or more hours of wear time on at least four days (Troiano et al. 2008, Hansen et al. 2012), nevertheless studies on large-scale populations reveal that between 6 to 32% of participants fail to meet this requirement for valid data (Pedisic & Bauman 2014).

Data from the Health Survey for England indicate that there are significant differences in socio-demographic and health characteristics between participants with valid accelerometer data (> 3 days of recorded data) and those with invalid data (< 3 day of recorded data) (Roth & Mindell 2013). They found that the people with invalid data were more likely to be young, smokers and more likely to be unemployed. This could suggest that the accelerometer data collected may not be generalizable to the general population or specific sub-populations.

Studies indicate that accelerometry is both reliable and valid; Sirard et al. (2011) investigated the test-retest reliability of adult accelerometry-measured PA in 143 participants, over two 7-day periods, using Actigraph accelerometers. Authors reported that test-retest reliability was very good to excellent (ICC = 0.70- 0.90), with no significant differences between PA measured at the two 7-day periods (Sirard et al. 2011).

Van Remoortel et al. (2012) conducted a systematic review examining the validity of activity monitors in healthy participants and those with chronic diseases (Van Remoortel et al. 2012). Authors reported that pooled correlations for uniaxial devices with doubly labelled water were 0.39 for activity energy expenditure (AEE) and 0.52 for total energy expenditure (TEE), a 0.59 correlation for AEE and 0.61 correlations for TEE for triaxial devices. Results from this review also showed that on average, uniaxial accelerometers underestimate both AEE and TEE by 24% and 12%, respectively, whereas triaxial devices underestimate AEE by 21% and TEE by 7%.

2.4.3 Role of physical activity and sedentary time in Type 2 Diabetes

PA is accepted to be an influential tool in the prevention and management of T2DM (Colbereg et al. 2010). However, fewer patients with T2DM manage to meet the minimum guidelines of engaging in 150 minutes of MVPA per week compared with the general population (Morrato et al. 2007). In 2003, Morrato and colleagues analysed self-reported data from 23, 283 people living in the US, with authors reporting that only 39% of people with T2DM were meeting minimum PA guidelines, compared with 58% of adults without T2DM.

With regards to sedentary time (ST) and premature mortality, Martinez-Gomez et al. 2013 conducted a prospective study showing that individuals who sat for less than 8 hours/day had a lower risk of all-cause mortality (HR = 0.70, 95% CI: 0.60 to 0.82) when compared with sedentary individuals. Pavey et al. (2012) reported a dose-response relationship between all-cause mortality and total ST. Authors indicated that individuals who totalled between 8-11 hours/day of ST (HR 1.35; 95% CI 1.09-1.66) and more than 11 hours/day of ST (HR 1.52; 95% CI 1.17-1.98) had a higher risk of all-cause mortality than those who averaged less than 8 hours/day.

A systematic review of clinical exercise interventions lasting 8 weeks or more in participants with T2DM was conducted by Boule et al. 2006. HbA1c was significantly lower in the groups prescribed exercise compared with controls (7.65 vs. 8.31%, weighted mean difference -0.66%; p<0.001). Meta-regression analysis showed that the favourable effects of exercise on HbA1c were independent of changes in body weight.

Epidemiological studies such as the Nurse Health Study (Hu et al. 2003), demonstrated that there was a 14% increase risk of T2DM with every 2-h/day increment of time spent watching TV. Conversely, each 2-h/day addition of non-sedentary activity was associated with a 12% decrease in risk.

Lamb et al. 2016 carried out a 4-year prospective study on 308 adults with newly diagnosed T2DM. Multivariable linear regression models were used to examine the associations between objectively measured PA energy expenditure (PAEE), ST, MVPA and clustered cardiometabolic risk (CCMR). Comparisons of data collected at baseline and at the end of the

4-year period revealed that individuals who managed to increase their PAEE throughout the 4-year period had a greater reduction in waist circumference (-2.84, 95% CI -4.84, -0.85) compared with the participants who reduced their PAEE. On the other hand, individuals who increased their ST experienced a greater increase in their waist circumference (3.20 cm, 95% CI 0.84, 5.56) (Lamb et al. 2016).

In 2006 a meta-analysis conducted by Thomas and colleagues looked at the effects of exercise on T2DM, in a pooled sample of 377 participants with T2DM from 14 randomised controlled trials. Analyses indicated that compared with controls, exercise interventions decreased HbA1c levels by 0.6%, (95% confidence interval (CI) -0.9 to -0.30; $p < 0.05$) (Thomas et al. 2006).

Another meta-analysis study indicated that structured exercise training programs consisting of aerobic and anaerobic activity were associated with significant reductions in HbA1c in patients with T2DM. However, the results also showed that PA advice was associated with lower HbA1c levels only when it was given in combination with advice to make dietary changes (Umpierre et al. 2011). Therefore interventions consisting of both exercise and dietary advice may be more optimal for managing T2DM.

A study by Hermann et al. (2014) examined the association between PA and glycaemic control. They analysed data from a large multicentre database in Germany and Austria which included 65 666 participants with T2DM. Authors reported that 90% of participants were classified as physically inactive. Both HbA1c and BMI were lower in participants in the group who were more active ($p < 0.001$) compared with the participants in the inactive group.

Results also indicated that insulin therapy was more prevalent in participants who were less active (Hermann et al. 2014). Interventions have also shown that patients with T2DM experience difficulties in being able to adequately increase their PA levels to show improvements in their cardiometabolic outcomes (Andrews et al. 2011).

Another meta-analysis conducted by Edwardson and colleagues concluded that the more time adults spent being sedentary, their odds of developing metabolic syndrome increased by 73 % (OR 1.73, 95% Cl 1.55-1.94, p<0.001) (Edwardson et al. 2012). Brocklebank et al. 2015 conducted a systematic review looking at the associations between accelerometer-measured ST with cardiometabolic biomarkers in adults (Brocklebank et al. 2015). Data analysed from the 29 studies showed a negative association between total ST and insulin sensitivity. Authors concluded that the negative association was consistent, even when adjustments were made for PA. The strength of this systematic review was that unlike previously published reviews, it used data from accelerometer studies as opposed to self-report data.

Another meta-analysis by Wilmont and colleagues further supports the relationship between ST and risk of T2DM. They conducted a large meta-analysis of 18 studies (16 prospective, 2 cross-sectional) consisting of 794,577 participants. They reported a 112% increase in the relative risk of diabetes (RR 2.12; 95% credible interval 1.61, 2.78) for the highest amount of ST compared with the lowest, consequently demonstrating the association between increased ST and an increased risk of developing T2DM (Wilmont et al. 2012) Therefore there is considerable data to support the importance of reducing ST and increasing PA when trying to decrease the risk of developing T2DM.

Joseph et al. compared self-reported sedentary behaviours in 5829 participants to diabetes risk as measured by fasting glucose concentrations. Results indicated that total leisure sedentary behaviours and television watching were significantly associated with diabetes risk (Joseph et al. 2016).

Following on from this study, van der Berg et al. investigated sedentary behaviours in relation to T2DM risk. In this cross-sectional study including 2,497 participants, researchers compared objectively measuring sedentary time to glucose metabolism as determined by oral glucose tolerance tests. Results indicated that 28.6% had T2DM, after conducting multinomial linear regression analysis authors concluded that an extra-hour of sedentary time was associated with a 22% increased odds of a participant having T2DM (van der Berg et al. 2016).

Similarly, a cross-sectional study conducted by Healy et al. 2015 looked at the association between accelerometry-derived ST and PA with cardiometabolic biomarkers in overweight/obese adults with T2DM. Results showed that both BMI and waist circumference were significantly ($p<0.05$) associated with higher levels of ST. Authors also reported a significant association between lower fasting plasma glucose and engaging in more light intensity activity (relative rate; 0.98, 95% Cl: 0.97, 1.00; $p<0.05$) (Healy et al. 2015). Thus, engaging in light PA may also confer health benefits in individuals with T2DM. The advantages of light PA was also highlighted by Yates et al. 2015, who used accelerometers to objectively measure the association between ST in 508 participants who were at risk of impaired glucose regulation. Results showed that transferring 30 min of ST into light-intensity PA was associated with a 5% (95% Cl 1, 9%; p= 0.024) improvement in insulin sensitivity. Furthermore, transferring 30 min of ST into MVPA resulted in a 18% (8, 28%; $p<0.001$) improvement in insulin sensitivity.

Hence these studies provide evidence for the importance of changing behaviours so that ST is reduced, while PA is subsequently increased in order to improve insulin sensitivity in participants who are at risk of impaired glycaemia (Yates et al. 2015). Furthermore, breaking up periods of sedentary behaviour can have positive effects on glycaemia. Dunstan et al. demonstrated that disrupting sitting time with short bouts of light walking significantly reduced postprandial glucose levels in overweight/obese adults (Dunstan et al. 2015).

2.4.4 Physical activity and South Asians

Self-reported data indicate that the prevalence of a sedentary lifestyle in South Asian immigrants is high, with Misra et al. reporting it at 60% for South Asian immigrants living in the US (Misra et al. 2000). Many factors such as low levels of acculturation (Jonnalagadda & Diwan 2005), limited social support (Kalavar et al. 2004) and racial discrimination (Misra et al. 2000) have been suggested as possible reasons for the high prevalence of sedentary lifestyles in these immigrant populations.

Babakus & Thompson (2012) conducted a mixed- methods review of PA among South Asian women living in the UK. Results demonstrated that the South Asian women had lower levels of PA when compared to both South Asian men and white European populations. Qualitative analysis revealed that a participant's culture was a common theme acting as a barrier to being physically active. Authors also reported that some women lacked knowledge about the amounts of PA required and the relative benefits of being more active (Babakus & Thompson 2012).

Curry & Thompson (2015) conducted a cross-sectional study comparing accelerometry-derived PA and ST to IPAQ-SF derived data from 140 South Asian women living in the UK. Authors reported that the mean MVPA was 242.62 ± 150.00 minutes/week, with mean ST as 530.20 ± 81.76 minutes/week. In contrast, data derived from the IPAQ-SF revealed a mean MVPA of 636.80 ± 2113.56) minutes/week and a mean ST of 315.31 ± 266.98 minutes/week. Further analysis showed no significant correlation between self-reported and accelerometry data for both MVPA ($r= -0.119$, $p=0.579$) and ST ($r= -0.140$, $p=0.229$). These results highlight that the IPAQ-SF may not be suitable for measuring PA and ST for this population.

Although the IPAQ has been translated into many languages, and the questionnaire can be administered by trained interpreters (as was done in the study by Curry & Thompson, 2015), there are challenges in translating terms and concepts into various languages where there are not words for 'physical activity' or clear translations addressing intensity of performing activities. Recognising these challenges, Curry & Thompson purposively selected a sub-sample of 24 of the women in their study to participate in semi-structured interviews. Findings suggested that some South Asian women had a lack of cultural contextualization around what health-related PA represents, as the concept of engaging in PA for any reason other than occupation is not recognised. These authors reported that some of the participants found it difficult to distinguish between varying intensities of PA along with a lack of familiarity with what the word 'sedentary' meant. The qualitative data from this study provides insights as to possible reasons for no correlations observed between self-reported and accelerometry data in this population. This study highlighted the limitations in using the IPAQ- short form with South Asian women and raised the importance of ensuring self-report methods are culturally tailored to ensure reliability.

Yates and colleagues (2015) investigated the differences between self-reported and objectively measure PA between 243 South Asians and 2843 White participants living in the UK. The IPAQ short form and accelerometers were used to measure self-reported and objectively measured PA, respectively. Data from the IPAQs showed that South Asians self-reported less MVPA (30 vs. 51 min/day $p<0.001$) compared with white participants. However, there were no significant differences between accelerometer-derived MVPA (18.0 vs. 21.5 min/day $p=0.23$). This study supports previous data highlighting the differences when assessing PA using self-report methods in South Asian populations (Babakus-Curry & Thompson 2014).

Most of the literature upon which the PA guidelines were constructed was carried out on white European populations (Warburton et al. 2010). Despite this, there is some evidence suggesting a dose-response relationship between PA and metabolic conditions that might be significantly different between the various ethnic populations (Celis-Morales et al. 2011). Celis-Morales and colleagues conducted a cross-sectional study to explore the amount of moderate intensity PA (MPA) South Asians would require to be able to present a comparable cardio-metabolic profile to that observed in a sample of active Europeans meeting the current recommendations of 150 min of MVPA per week. The study included 75 South Asian and 83 European men aged between 40 and 70 years who did not have diabetes. Fasting blood samples were taken to assess cardiometabolic risk profiles, and accelerometers were used to determine levels of PA. Factor analysis was used to summarise measured risk from biomarkers, and age-adjusted regression models were used to calculate the equivalent levels of MVPA needed in the South Asian men to elicit the same value for analysed factors in the Europeans who were meeting the PA guidelines. Results showed that for all factors except blood pressure, the equivalent MVPA values for South Asians were significantly higher than 150 min per week. In fact, the equivalent MVPA needed to meet the cardio-metabolic profiles of their European counterparts was 266 (95% CI 185-347) minutes per week. The authors concluded that South Asians might need to undertake higher levels of PA to achieve the same cardio-metabolic benefit obtained in European populations (Celis-Morales et al. 2013). Future work will need to investigate this finding further to determine if it is necessary to set specific PA guidelines based on ethnic origin and/or metabolic risk factors.

2.4.5 Conclusion

Currently, there is limited objectively measured data on PA and ST amongst South Asian adults. In order to design diabetes prevention interventions for the high-risk group of South Asian men, it is essential first to be able to quantify their current state of PA, inactivity, and ST, as well as to explore the factors which influence these behaviours in this population.

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CHAPTER 3

METHODOLOGY

3.1 Methodology

This chapter will describe the methodological approach employed to examine the dietary and physical activity characteristics of overweight and obese South Asian men living in the UK. The chapter begins with a justification of why a mixed-methods approach was chosen, along with a discussion of the theoretical framework that underpinned the research. Both quantitative and qualitative methods are described in detail, however the methodology used for the systematic review will not be discussed as it has been covered in Chapter 4.

3.1.1 Mixed-methods research:

The mixed-methods approach has developed into the third paradigm for social research (Johnson et al. 2007). As a research paradigm, the mixed-methods approach consists of a specific group of ideas and processes, which sets apart this approach from other paradigms. Mixed-methods research has its origins in the early 20th century, being initially utilised by both fieldwork sociologists and anthropologists (Cresswell 1999, Johnson et al. 2007). Research paradigms have always been evolving. Early use of the positivist paradigm (related to quantitative methods) was initially dominant, later progressing to a time where constructivist paradigms (related to qualitative research methods) were viewed as feasible alternatives. The mixed-methods research paradigm emerged in the 1990s, vesting itself along side the other paradigms, so that ‘we currently are in a three methodological or research paradigm world, with quantitative, qualitative, and mixed methods research all thriving and coexisting’ (Johnson et al. 2007).

The mixed-method paradigm has now evolved to the point were it has its own distinct worldview, along with techniques and vocabulary unique to its own (Tashakkori and Teddlie 2003). Authors such as Creswell (2003) and Tashakkori and Teddlie (1998) have captured the practices representing the foundations of the mixed-methods paradigm. These authors along with others have defined a list of characteristics, which define the mixed-methods approach:

- Use of quantitative and qualitative methods within the same research.
- A research design that openly defines the order and priority given to the quantitative and qualitative components of data collection and analysis.
- A clear account of how the quantitative and qualitative components of the research relate to one another.
- Use of pragmatism as the philosophical underpinning for the research

  (Descombe 2008)

Pragmatism is commonly considered to be the philosophical accomplice of the mixed-methods approach. This present thesis was guided by pragmatism, where the study design materialised directly from the research questions being examined (Creswell and Plano Clark 2011).

There are three main purposes to mixed-methods research:

1. Using a mixed-methods approach to enhance the accuracy of the data.
2. To develop a more thorough understanding of a phenomenon, by combining information from different types and sources of data.
3. To minimise intrinsic bias of using a single-method approach, hence compensating for weakness of either a quantitative or qualitative approach

   (Denscombe 2008)

The quantitative approach has been the main method used for research in the area of nutrition and PA (Swift & Tischler 2010, Kassam-Khamis et al. 2000, Sevak et al. 1994), but in recent years mixed-method designs have become more popular (Stathi et al. 2012, Huynh et al. 2015, Castaneda-Gameros et al. 2016).

This present thesis aims to examine the dietary and PA characteristics of overweight and obese South Asian men living in the UK. Therefore due to its pragmatic nature, a mixed-methods approach was utilised to examine these behaviours in more detail.

3.1.2 Theoretical framework:

A phenomenological approach is the approach of studying an experience from the perspective of the participant being research (Husserl 1970). The essence of phenomenological exploration looks to describe rather than to explain, and to begin from a viewpoint free from hypothesis or previously established inclinations (Husserl 1970). A phenomenological approach was utilized to conceptualize, create and execute all phases of the study This approach concentrates on the mutual experiences of a certain group, while allowing the researcher to understand the significance of those shared experiences (Creswell 2013). The mutual experience of being an overweight and obese South Asian man living in the UK was the phenomenon studied in relation to PA, ST and eating behaviours. Within the constructs of this approach a Community Energy Balance (CEB) (Kumanyika et al. 2012) framework was implemented as the foundation upon which internal and external influences of PA, ST and eating behaviours were explored. This framework suggests that the physical activity and eating behaviours influencing energy balance in migrant populations, are not merely the product of their individual behaviours but the combined result of a lifetime of experiences influenced by political, historical and structural circumstances. The CEB framework highlights the potential for stress caused by these cultural interactions, to have a negative impact on the development of long-term physical activity and eating behaviours. Components within the framework underline the significance of community based participatory research (CBPR) in order to best utilise community assists to better help benefit its members (Kumanyika et al. 2012).

Frequently used ecological frameworks implemented to understand the phenomenon of obesity in populations, acknowledge that interactions exist between an individual and their physical, economic, political and socio-cultural environments (Swinburn et al. 1999). Nonetheless ecological frameworks developed for use in ethnic minority populations are both limited and lacking in the use of structural variables to define cultural contexts (Kumanyika et al. 2007). The cultural and contextual considerations articulated in the CEB framework relevant to behaviours effecting energy balance, concentrate on the unique influences which distinguish ethnic minority groups from their host populations (Kumanyika et al. 2012), therefore making the CEB framework a better suited model for use in this current study.

3.1.3 Mixed-methods design:

The mixed-methods approach used in this study employed a concurrent triangulation design (Cresswell 2003). In this design both quantitative and qualitative data were collected at the same time, with data being integrated at the interpretation phase. As the results of the quantitative component did not directly effect the qualitative investigation, this design was the most effective, allowing for the limited time available with participants to be utilised efficiently. Furthermore equal priority was given to both quantitative and qualitative components, to ensure that both methods were proportionately applied to understanding the phenomenon being investigated. Data collection was divided amongst two separate visits, one week apart. Visit 1 focused on dietary intake and eating behaviours, whereas visit 2 focused on physical activity and sedentary time characteristics. Socio-demographic, physical test and functioning data were all also collected during the first visit. Figure 3.1 displays how each section of the mixed-method design was formulated.

3.1.4 Mixed-methods design schematic:

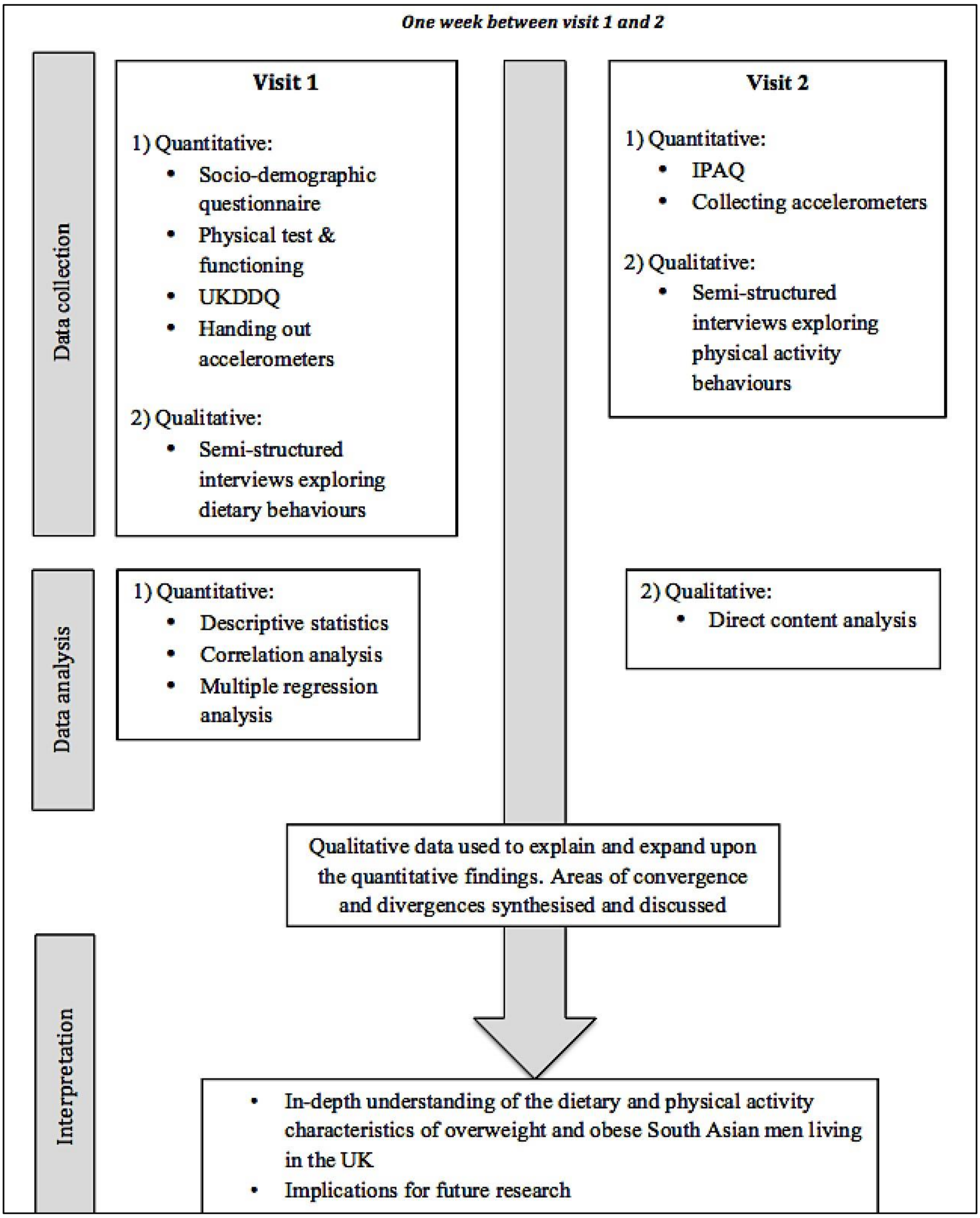

Figure 3.1 Schematic of mixed-method design used.

3.2 Recruitment, ethics and data handling

The following section will describe the processes by which participants were recruited, along with the ethical considerations of the research.

3.2.1 Recruitment and participants:

Participants were eligible to participate if they were men of South Asian origin, were between the ages of 18 to 64, had not been previously been diagnosed with T2DM, had a BMI of over 23.0 kg/m^2, and did not need assistance for walking or climbing stairs. As there was no funding for translators only those fluent in English were deemed eligible. Additionally participants with health conditions that affected memory (Alzheimer's or dementia) were excluded.

The recruitment process initially involved developing close ties with the various South Asian communities. This was achieved by visiting mosques, temples and community centres to discuss the research with community leaders. This was followed by advertising in local newsletters and running Diabetes awareness days at the various temples to engage with members of the community. All participants were recruited from the greater London area. The main recruitment locations included:

1. Sing Sabha London East (Sikh Temple in Ilford)
2. Brent Sikh Centre (Sikh Temple in Brent)
3. Harley Grove Gurdwara (Sikh Temple in Bow)
4. Amersham Indians (Community centre in Amersham)

5. Sri Guru Singh Sabha (Sikh Temple in Southhall)
6. Brent Civic Centre (Community centre in Brent)

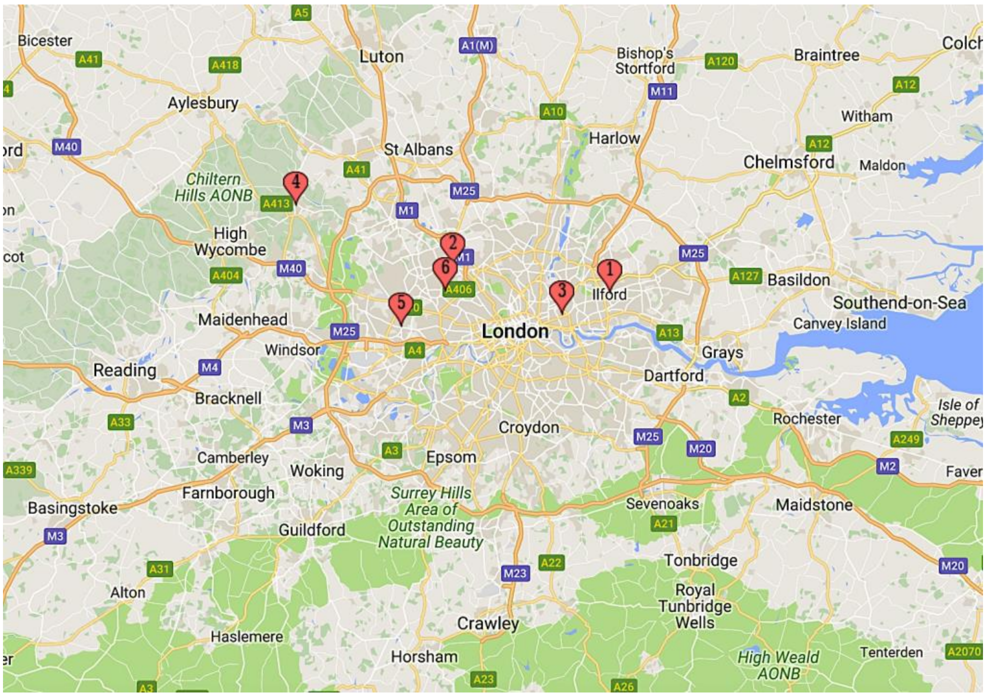

Figure 3.2 Map showing locations of main recruitment centres (*image from www.google.co.uk/maps/)*

3.2.2 Ethical considerations:

This study was approved by the ethical review committee of the University of Birmingham (reference # ERN_15-0518). All participants were provided with a participant information sheet, which explained the purpose of the study, what was required from them, and were told of the benefits and risks associated with taking part. To confirm participation, all participants signed an informed consent form to confirm that they voluntarily agreed to take part in the study. Participants were also informed that there were no consequences if they decided to withdraw, with all corresponding data being destroyed if they did.

Data collection was conducted either at the participant's home, or at a their place of work; ensuring privacy and safety for the participants. General safety procedures were followed, these included: informing supervisor of dates and times when data collection was taking place, and having access to a mobile phone at all times, in case of emergencies. Furthermore the primary supervisor was always, available for help and guidance if any problems arose.

3.2.3 Data protection:

To ensure confidentiality, all participants were assigned a corresponding numeric ID code, which was only known to the researcher and supervisor. The document linking the participant's name to their numeric ID code was kept in a locked cabinet in a locked office separate from any other documents to prevent identification. All documents and audio files were locked in a filing cabinet. All audio-recorded files were subsequently erased after transcription.

3.3 Quantitative data collection and analysis

This section will describe how the quantitative data was collected, processed and analysed.

3.3.1 Socio-demographic questionnaire:

A pre-designed self-report questionnaire was used to collect socio-demographic data including age, country of birth, ethnicity, religion, marital status, number of children, number of years living in the UK, English literacy, level of education, use of medication and current residential postcode. Residential postcodes were used to determine an Index of Multiple Deprivation (IMD) ranks, which were used as an indicator of compound social and material deprivation (UK Government 2015). The IMD rank is a measure of the relative deprivation in small areas of England, ranking areas from 1 (most deprived) to 32,844 (least deprived). Scores are calculated based on a list of attributes associated to a specific area including ratings of employment, education, healthcare and crime (UK Government 2015).

3.3.2 Anthropometry:

Participants' height was measured (to the nearest 0.5 mm) using the Seca Stadiometer, weight was measured (to the nearest 0.01kg) using the Seca 899 Digital Scale (Seca, Birmingham, UK) for both measures participants removed their shoes and any excess clothing. BMI was then subsequently calculated by divided weight in kg by the square of height in metres. Blood pressure was measured at rest using the Omron M10-It monitor (to the nearest mmHg) (Omron, Milton Keynes, UK), after 5 minutes of seated rest. Handgrip strength (HGS) was assessed using the Jamar hand dynamometer (to the nearest Kg Force) and waist circumference was measured at above the umbilicus using a standard tape measure (to the nearest 0.5 cm). All measurements were recorded three times, with the mean of the two closest taken as the final measurement.

3.3.3 UK Diabetes and Diet Questionnaire (UKDDQ):

UKDDQ is a 25-item questionnaire designed to assess diet and dietary behaviours in adults with, or at risk for, T2DM (*see Appendix 3*). The questionnaire has been shown to be a reliable and valid measure of diet when compared with a 4-day food diary (England et al. 2016). There are two versions of the questionnaire; one is self-administered with the other being interviewer-administered. In order to ensure accurate data entry as well as enabling the participants to discussion any points of confusion, the interviewer-administered version was used.

3.3.4 International Physical Activity Questionnaire (IPAQ):

In order to measure total moderate to vigorous physical activity (PA) and sedentary time (ST), the self-administered version of the IPAQ-long form was used (*see Appendix 4*). The IPAQ-long form is a questionnaire used to recall PA and ST in adults aged between 18-65 over a 7-day period, and has been validated in over 12 countries (Craig et al. 2003). The long-form of the questionnaire assesses PA and ST over 5 different domains; 'work-related', 'transport', 'leisure time', 'domestic and garden' and 'time spent sitting'. The durations (in min) and frequency (in days) reported across all 5 domains was then used to generate an output for PA and ST. Further more the minutes/week (min/wk) that were generated for the PA measures were subsequently multiplied by a metabolic equivalent of task (MET). METs are assigned to different forms of activity based on the level of intensity, walking = 3.0, moderate = 4.0 and vigorous = 8.0), to give a final output for PA in MET min/wk.

3.3.5 Objectively measured PA and ST (Accelerometery):

The ActiGraph GT3X accelerometers (ActiGraph, Pensacola, FL, USA) were used to objectively measure PA and ST. This accelerometer was used as data recorded using the GT3X model has been shown to be both valid and reliable throughout all age groups (Santos-Lozaro et al. 2013). Participants were asked to wear the accelerometers on their right hip during waking hours for 7 consecutive days, and instructed to only remove the monitors when sleeping, showering or swimming. Along with the accelerometers participants received an information sheet, with a diagram of how to wear the accelerometer, as well as a reminder of the importance of wearing the monitors for the whole day. The contact details of the researcher was also given, in case any assistance was required.

Once the accelerometers were collected at visit 2, the data was downloaded and analysed using the Actilife 6 data analysis software. An epoch of 60 seconds was chosen for analysis (Dinesh et al. 2010), with a minimum 600 min of wear time used as the cut-off point for a valid PA, only participants with a minimum of 4 valid days of data were including in analysis (Troiano et al. 2008, Celis-Morales et al. 2013). Non-wear periods were defined as greater than 60 consecutive minutes with zero activity counts. The Freedson (1998) cut-off points were used to determine the time spent in various levels of PA (0–99 counts/min = sedentary, 100–1951 counts/min = light intensity activity, 1952–5724 counts/min = moderate intensity activity, 5725–9498 counts/min = vigorous intensity activity, and >9499 = very vigorous intensity activity). These cut off points have been previously used in South Asian populations, therefore were deemed appropriate for this study (Curry & Thompson 2015, Celis-Morales et al. 2013). As the IPAQ long form calculated activity in METs/wk, for the purpose of comparing accelerometer to IPAQ derived MVPA, accelerometer data was also converted to MET min/wk (4 x min of moderate intensity activity + 8 x vigorous intensity activity).

3.4 Qualitative data collection and analysis

This section will describe how the qualitative data was collected, processed and analysed.

3.4.1 Semi-structured interviews:

Two purposive sub-samples of participants from the original sample were also asked to take part in one to one, semi-structured interviews, which were conducted during both visits of the study. Participants were purposively selected to provide maximum variation across age, ethnicity, faith, years living in the UK, and level of deprivation. The first interviews regarding diet and eating behaviours were conducted at the end of visit 1 (n = 36), with the second interviews being conducted at the end of visit 2 (n = 31), once participants had returned their accelerometers. Each of the two sets of interviews were guided by their own open-ended interview guides which were used to facilitate the discussions (*see Appendix 5 and 6)*. Both interview guides were pilot tested on three South Asian men in order to appraise the interview schedule prior to commencing the study, with further amendments being made throughout the data collection phase using an iterative process. The first interview was led by a list of themes including the perception of T2DM, importance of dietary intake, barriers and facilitators to making dietary changes and the sociocultural factors influencing dietary changes (Figure 3.2). The second interviews were guided by a list of topics relating to the perception of PA and ST, importance of physical activity, barriers and facilitators to being more active, and the sociocultural factors influencing PA and ST (Figure 3.3). The theoretical framework, previously described, guided both interview schedules (*see appendix 5 & 6*). All of the questions were open ended and various. As all the participants could speak sufficient English, there was no need for translators. Interviews were audio recorded and then transcribed verbatim.

Figure 3.3 Topics covered in interview schedule (Visit 1)

- Perception of Type 2 Diabetes
- Importance of dietary intake
- Barriers and facilitators to making dietary changes
- Sociocultural factors influencing dietary changes

Figure 3.4 Topics covered in interview schedule (Visit 2)

- Perception of physical activity and sedentary time
- Importance of physical activity
- Barriers and facilitators to being more active
- Sociocultural factors influencing physical activity and sedentary time

3.4.2 Interview setting:

Both interviews recorded at visit 1 and 2 lasted between 5-20 minutes each and where conducted either at the participants home or place of work. Flexibility as to where the participants wanted to be interviewed ensured that they felt safe and comfortable to participate in the interviews.

3.4.3 Direct content analysis:

Direct content analysis was used as the method for analysing the transcribed interviews. This method is suitable for qualitative data analysis when there is already pre-existing research on the phenomenon being investigated (Hsieh & Shannon 2005). On this occasion there is some research on enhancing diet for health promotion, along with the barriers to making dietary changes in South Asian men (Cross-Bardell et al. 2015, Hempler et al. 2015). The existing research also steered the process for constructing the interview guide. NVivo qualitative data analysis software (v11.1.0, QSR International, Australia) was used to sort and code the transcribed data. Throughout the process of developing the interview guide, major themes and concepts developed, these were then used as the main coding categories for analysis. All transcripts were coded using the main coding categories, with a selection of transcripts being coded by a second researcher to confirm agreement in coding. Data that did not fit into the initial categories were further analysed to see if they needed to be re-classified as a new category. Once the final coding categories were determined, the data was re-visited and coded for based on the final coding categories.

3.4.4 Coding:

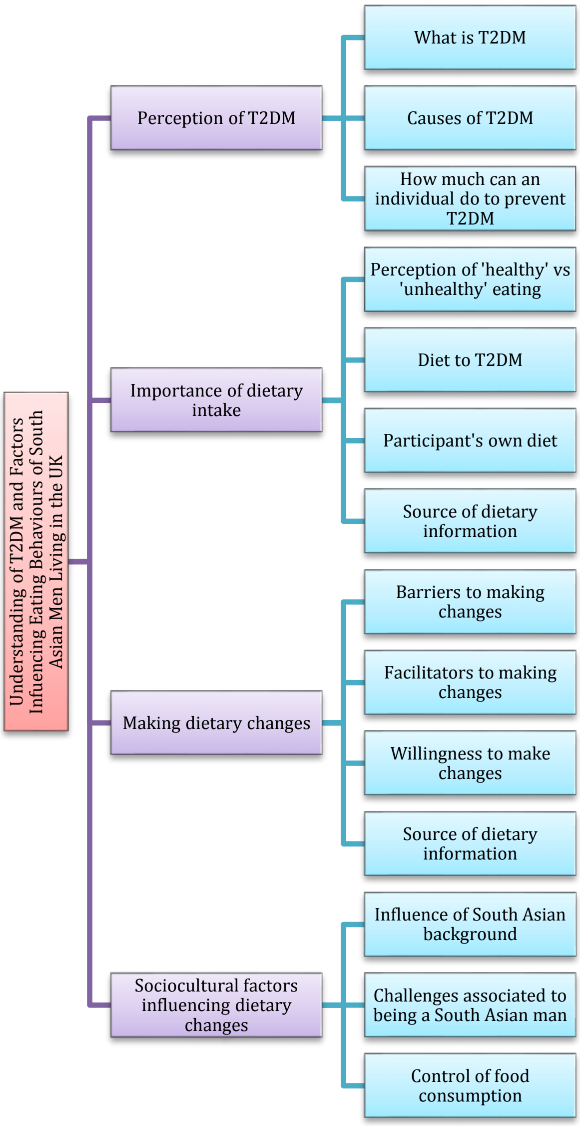

Figure 3.5. Diagram showing the final coding matrix for the dietary data

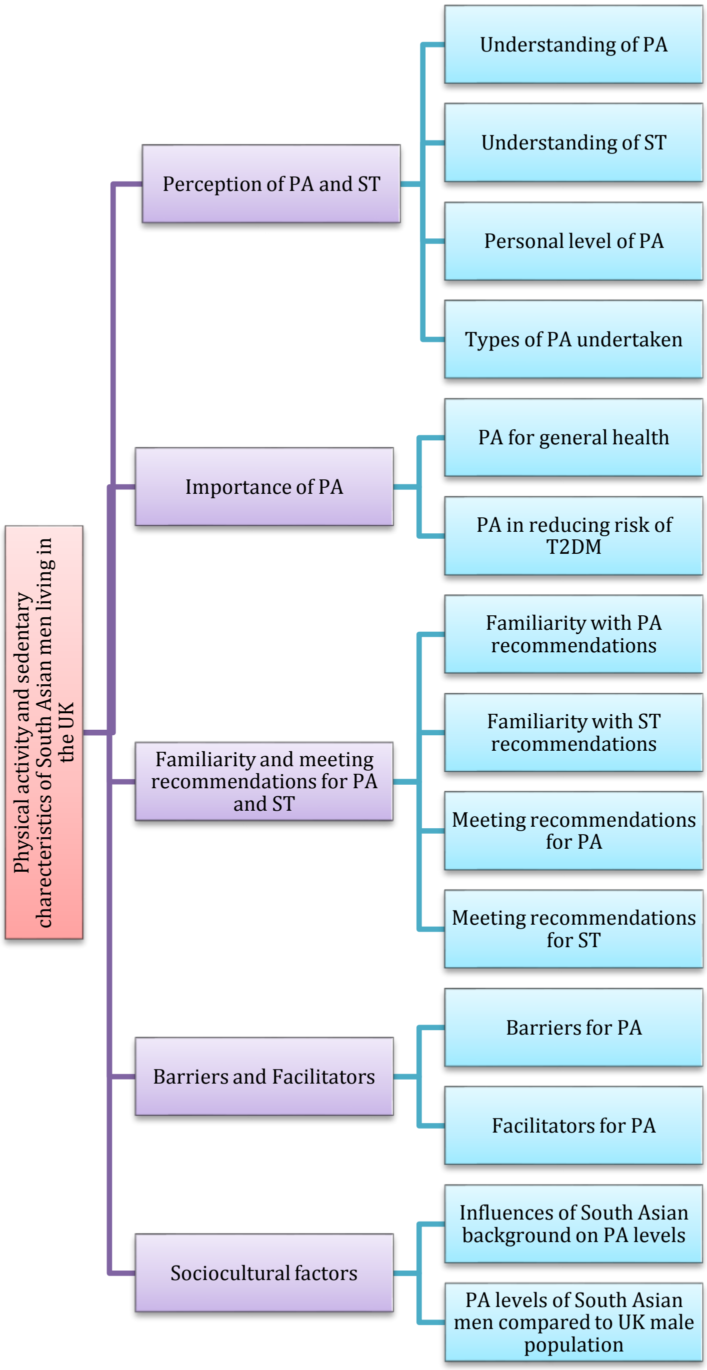

Figure 3.6 Diagram showing the final coding matrix for the PA and ST data

The initial interview guides, along with the subsequent themes and sub-themes, which emerged during the data collection process, were used to construct the final coding matrix shown in Figure 3.4 and 3.5.

Table 3.1 Example of a transcript extract with codes applied

Transcript Extract	Code
What does 'healthy eating' mean to you?	
Eating healthy means you can have everything, but in proportion, and not have twos of things or threes of things. You know, instead of having, maybe have a piece of chocolate than a bar of chocolate. It could eating a little bit more veg, it could be smaller, smaller portions of what you're having. You know, it's, uh, controlling what you're already eating, but having less[1].	1. Perception of 'healthy' vs. 'unhealthy' eating
Because I think in general I know of my diet, I think where I get let down is the snacking. You know, at home I eat fresh food, at breakfast I normally have Weetabix and I have good food[2].	2. Participant's own diet
It's the snacking that really let's me down, it's the in between bit that I need to control. That's me, personally, because I think I don't eat too much. I do eat a couple of takeaways a week, which I think I should really cut down on, but the biggest thing for me is - because I get enough fresh fruit in my diet, and fresh, um, vegetables, probably, you know, some are better than others - but the thing that really let's me down is the snacking[3].	3. Barrier to making dietary changes

3.4.5 Trustworthiness:

A sub-set of transcripts (n=6) were also coded for independently by a second researcher. After in-depth discussion and subsequent agreement, the coding matrix for both the diet and PA interviews were confirmed. The initial coding frames were revisited and changed to ensure agreement between both researchers. Specific quotes form the participant’s transcripts were used in the results section to inform the readers of the origins and accuracy of any conclusions made. Furthermore the reflexivity provided will ensure that readers are aware of any possible data bias due to the researchers previous background and/or prejudices (Ellingson 2006).

3.4.6 Reflexivity:

In order to provide transparency and to ensure trustworthiness it is important to provide a brief background about me, the researcher, therefore this section of the thesis will be written in the first person.

I am a nutritionist with previous experience as a quantitative researcher. My lab-based, MSc thesis involved using gas-chromatography, mass-spectrometry to assess the use of alkylresorcinols as a biomarker for whole-grain intake. After completing my MSc in Nutrition, I spent a year working as a personal trainer in commercial gyms. From this experience I the gained skills needed to work with people in a real-world setting. The hands on experience I gained learning about the dietary and physical activity behaviours of the clients I was working with, helped develop a strong interest in wanting to understand more about the contextual factors influencing these behaviours.

Having come from a quantitative lab-based background, this study was the first time I was implementing both qualitative research and working within a community setting. However I do believe my experience working with clients a personal trainer did provide me with sufficient social skills to make it easier for me to adapt to this research approach. Not being from the same cultural background as the participants in my research was a limitation, however my own personal background did benefit me when attempting to engage with the community. Although I was born in Tehran, Iran I was raised in London from the age of one. Living in such a multi-cultural environment has enabled me to gain experience interacting with a wide range of people from different cultural backgrounds, which has made me better suited to engage with ethnic minority populations. Also having many South Asian friends did provide me with some basic prior knowledge about the cultural and religious backgrounds of the study population.

My initial attempts to contact South Asian community groups, through telephone and email yielded very low results. I learnt quickly that engaging with the South Asian communities had to be done face to face. Visiting the places in person and discussing the study with members of the management teams enabled me to better engage with respective communities. Certain communities were more difficult to initiate contact with, but I acknowledged that being introduced by someone from that community greatly helped me gain their trust and acceptance. In one example, my friends' father who was well know in the Sikh community in Ilford, personally took me to meet the elders at his local Gurdwara (Place of worship). This gave me the platform needed to discuss my research with them and this ultimately led to very beneficial relationship with the temple through which many participants were recruited.

Being from a Muslim background, it was easier for me to engage with Bangladeshi and Pakistani community, as I was more aware of the religious customs when entering a mosque. On the other hand I knew little about the Sikh faith. Therefore I made sure before hand to research the main customs I needed to know before entering places of worship. This included dressing appropriately and ensuring my hair was covered when entering a Gurdwara. Small things such as accepting offerings of tea, knowing who's hand I should and should not shake made a significant difference in how I was perceived by the community, and ultimately the success of my recruitment. It is important to note that the community I was working with were quite traditional and when working with male participants, being male myself definitely made things a lot easier. In particular when engaging with participants in places of worship, being male was hugely advantageous.

Once access to the community was gained, the next challenge was recruiting the participants who met the inclusion criteria for the study. The major hurdle I faced was the issue of trust. I was viewed by many as an outsider and some believed that participation in the research would have a financial cost. I utilised different strategies to overcome these hurdles. In one Gurdwara, I managed to get a poster of the study published in the local newsletter for members to read in advance. Being endorsed by the temple management made the study more acceptable to the members, and increased interest in the research. Secondly I wanted to make sure the community understood that I was there not just to take but also to give back. In order to engage with the whole community and not just the male participants I needed for the study, I ran 'blood pressure screening days'. During these events, which took place on Sundays, I set up a stand where I offered free blood pressure screenings for everyone, while handing out Diabetes UK information sheets, both in English and in Punjabi. Although most who engaged where women or men over the age of inclusion, it was very successful in building trust with the community as a whole, later leading to more suitable candidates wanting to engage with the research.

One thing I learnt was that within South Asian communities there were distinct differences in culture between the varying ethnic backgrounds. As a result it was necessary for me to be aware of these differences to ensure the best rapport could be developed with each participant. While discussing the role of family and the effects of eating behaviours during the interviews, I discovered many similarities with my own Iranian family. I new it was important to remain objective so I made sure to minimise the bias I could introduce to the conversation, in order to allow the participants to freely express their own personal views.

Trust was a key theme throughout the study. Even once participants agreed to take part, there were concerns over data protection. In one particular community in Amersham, they had past experience with data fraud and as result were concerned about how their personal information was going to be handled. I ensured them that their privacy was my priority, and put them at ease by directing them to their participant information sheets, which had a section on confidentiality, explaining how and where their data will be used and stored. I also explained that they would be given numerical codes and that their names would not be used in any future publications.

Although most of the participants did have good English speaking skills, some were weaker communicators than others. In order to account for this, times when I believed they were struggling to understand me, I was conscious to speak very clearly and often slowed down my speech to ensure they understood the questions being asked. Also some of the men did have strong accents, which was at times challenging. When there were moments that I could not understand what the participants were saying, I politely asked them to repeat themselves, to ensure I did not miss any key information. Throughout the interviews I had a written journal were I noted all key observations that I believed would be useful for data analysis.

Overall I gained many skills during this experience and learnt a great deal about the social aspect of community research, and in particular the importance of trust building when engaging with ethnic minority populations. I considered these new skills and experiences to be highly valuable and I am sure they will greatly help me in my future career.

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THE EFFECT OF MACRONUTRIENTS ON GLYCAEMIC CONTROL: A SYSTEMATIC REVIEW OF DIETARY RANOMISED CONTROLLED TRIALS IN OVERWEIGHT AND OBESE ADULTS WITH TYPE 2 DIABETES IN WHICH THERE WAS NO DIFFERENCE IN WEIGHT LOSS BETWEEN TREATMENT GROUPS

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4.1 Abstract

Weight loss is crucial for treating type 2 diabetes mellitus (T2DM). It remains unclear which dietary intervention is best for optimizing glycaemic control, or whether weight loss itself is the main reason behind observed improvements. The objective of this study was to assess the effects of various dietary interventions on glycaemic control in overweight and obese adults with T2DM when controlling for weight loss between dietary interventions. A systematic review of randomized controlled trials (RCT) was conducted. Electronic searches of Medline, Embase, Cinahl and Web of Science databases were conducted. Inclusion criteria included RCTs with minimum 6 months duration, with participants having BMI ≥25.0 kg/m^2, a diagnosis of T2DM using haemoglobin A1c (HbA1c), and no statistically significant difference in mean weight loss at the end-point of intervention between dietary arms. Results showed that 11 studies met the inclusion criteria. Only four RCTs indicated the benefit of a particular dietary intervention over another in improving HbA1c levels, including the Mediterranean, vegan and low Glycaemic Index diets. However the findings from one of the four studies showing a significant benefit are questionable due to failure to control for diabetes medications and poor adherence to the prescribed diets. In conclusion there is currently insufficient evidence to suggest that any particular diet is superior in treating overweight and obese patients with T2DM. Although the Mediterranean, vegan and low Glycaemic Index diets appear to be promising, further research that controls for weight loss and the effects of diabetes medications in larger samples is needed.

4.2 Introduction

Dietary intake is recognized as a major contributor to both the development and management of type 2 diabetes [(1)]. The current American Diabetes Association (ADA) recommendations for overweight and obese patients with type 2 diabetes (T2DM) include reducing energy intake while maintaining healthful eating patterns in order to promote weight loss [(2)]. Different diets have been studied to determine their impact on the management of T2DM. With regards to prevention, a recent meta-analysis of prospective cohort studies comprising of 21 372 cases demonstrated that healthy diets (e.g., Mediterranean diet, Dietary Approaches to Stop Hypertension) were equally associated with a 20% decreased risk of developing T2DM [(3)]. However, there remains no conclusive evidence as to which diet, if any, is the most effective in optimizing glycaemic control in patients with T2DM [(4)].

Two systematic reviews have examined the effects of different dietary interventions in managing T2DM. Ajala et al. (2013) [(5)] investigated the effects of low-carbohydrate, vegetarian, vegan, low-GI, high-fibre, Mediterranean, and high-protein diets as compared to control diets (low-fat; high-GI; low protein and diets described as following guidelines of the ADA or European Association for the Study of Diabetes). They concluded that the Mediterranean, low-carbohydrate, low-GI and low protein diets resulted in greater improvements in HbA1c when compared with their respective controls, with the Mediterranean diet having the greatest effect. Meta-analyses also indicated that both the Mediterranean and low-carbohydrate diets produced the greatest weight loss (-1.84 kg and -0.69 kg, respectively).

Wheeler et al. (2012) [6] conducted a systematic review that took a different approach. They examined the impact of macronutrients, food groups, and eating patterns on diabetes management and risk for cardiovascular disease (CVD). This was a follow-up to the literature review published by the ADA in 2001, and thus the authors only included studies published from 2001 to 2010. The authors concluded that many diets improved glycaemic control and cardiovascular risk factors; however no one diet was identified as superior.

Both of these systematic reviews included studies in which the diets being examined resulted in greater weight loss than the respective “control diet,” making it difficult to determine whether the improvement in glycaemic control was due to weight loss or the composition of the diet. There is a need for a new systematic review to address this limitation. Thus, the aim of this systematic review was to analyse the results from only randomized controlled trials where different dietary interventions were compared, and in which the total mean weight loss between groups was not statistically significantly different. If this analysis indicates significant improvements in glycaemic control, this would suggest that a particular diet may be more optimal for diabetes management.

4.3 Methods

4.3.1 Criteria for study consideration - types of studies and participants:

Only randomized controlled trials with a minimum duration of 6 months and a measure of HbA1c were considered for this review, in order to examine long-term changes in HbA1c. The review set out to investigate the effects of dietary interventions in overweight and obese adults with T2DM, so only studies in which participants had a BMI of 25.0 kg/m^2 or higher, along with a confirmed diagnosis of diabetes in line with the WHO diagnostic criteria [(7)], were considered for inclusion. Studies needed to have at least two arms examining differences between dietary interventions. As the main aim of this study was to examine the impact of various diets on T2DM management independent of differential effects of weight loss, only trials in which there were no statistically significant differences in the mean weight lost between the arms were considered for inclusion. Studies including pharmacological or physical activity interventions were excluded. Only interventions using a whole-diet approach were of interest, so trials involving individual foods, functional foods or individual supplements were excluded.

4.3.2 Outcome measures:

The main outcome of interest for this review was the mean difference in HbA1c between dietary arms at the end point of intervention.

4.3.3 Search strategy:

Electronic searches were conducted in Medline, Embase, Cinahl and Web of Science databases including all studies published as of June 29th, 2015. References of included studies along with published reviews were hand searched for additional studies. Individual search strategies were developed according to the specifications of the different databases. A combination of exploded MeSH headings and free text searching was used as part of the search strategies. MeSH headings used included, ‘Type 2 diabetes’, ‘NIDDM’, ‘Haemoglobin

A, Glycosylated', 'Diet', 'Dietary proteins', 'Dietary fats', 'Dietary carbohydrates', 'Glycaemic index', Glycaemic load' and their variants. The search was limited to studies written in the English language. (*See Appendix 1*)

VW who was our research librarian, was instrumental in working with the lead author (AE) to develop and finalise the search strategy for the four databases. AE screened all titles and abstracts and initially assessed studies for inclusion. Where it was unclear whether a study met the inclusion criteria, a second author (JLT) screened the reports.

4.3.4 Study quality assessment and data extraction:

The lead author (AE) rated the quality of the randomized controlled trials identified by the searches using the Joanna Briggs Institute (JBI) [8] critical appraisal tool to ensure trials were of a sufficient quality (*See Appendix 2*). A second independent reviewer rated the quality of a sub-sample of 20 relevant articles. Data extraction was then conducted by AE and an independent reviewer on the final 11 articles that met all inclusion criteria, using a custom designed data extraction sheet.

Due to the published studies lacking a common control diet for comparison, it was not possible to conduct a meta-analysis of the results from the included studies. Thus the results of a qualitative synthesis are reported here.

4.4 Results

4.4.1 Study selection

Through initial electronic database searching and hand searching, 705 studies were identified (**Figure 4.1**). After removal of duplicates, this was reduced to 525 studies. The initial stage of assessing studies focused on excluding studies based on information present in the titles and abstracts, which resulted in the elimination of 540 studies. A total of 20 remaining studies were then accessed in full text form to further assess eligibility. Of these 20 studies, 9 were excluded as they failed to meet one or more of the inclusion criteria (Figure 4.1). The remaining 11 studies met all inclusion criteria and after critical appraisal were deemed to meet the quality requirements to be included in the qualitative synthesis.

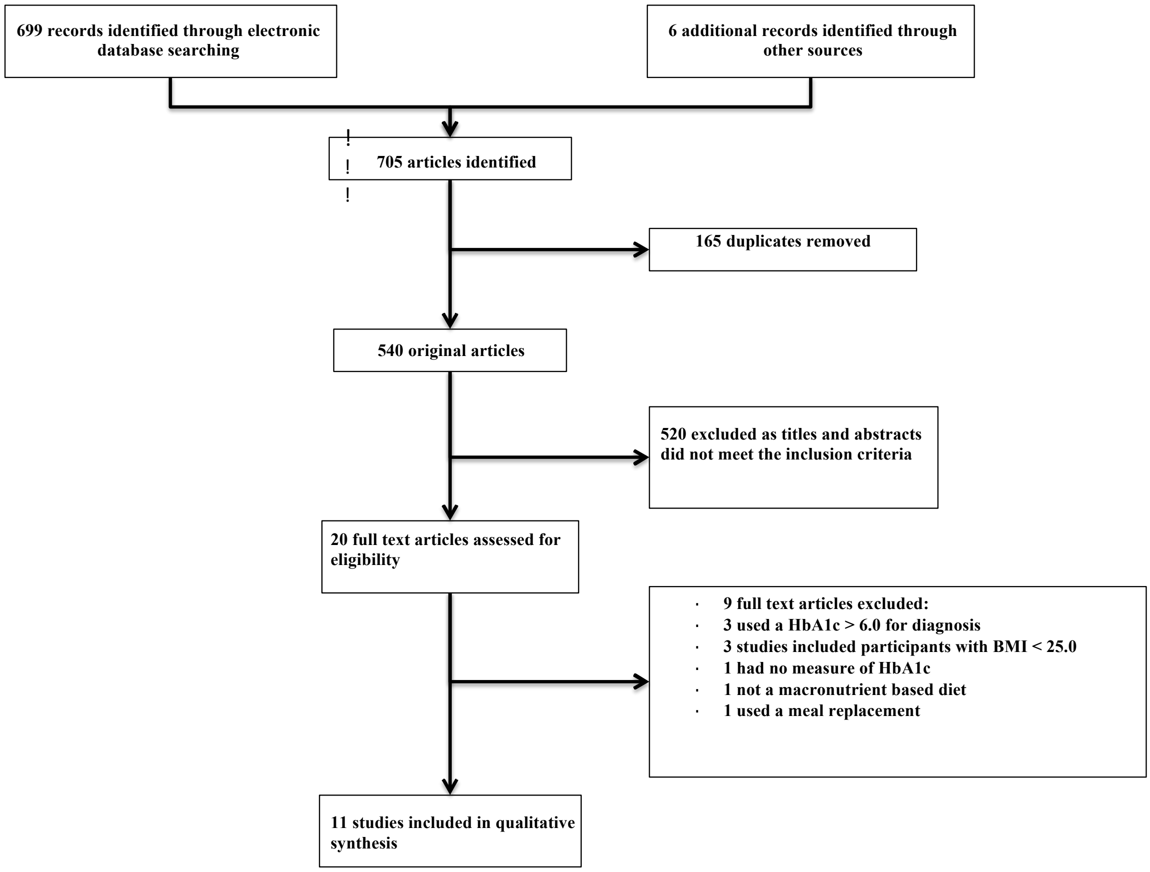

Figure 4.1 Flow diagram showing the number of studies screened, assessed for eligibility, and included in the review. RCT, randomized controlled trial.

4.4.2 Participants and participants' characteristics

The 11 studies included in this review are summarized in **Table 4.1**. The duration of the interventions ranged from 40 weeks [9] to 4 years [10]. The trials varied in size, with the smallest study including 40 [11] participants and the largest study including 259 [12] participants. The pooled sample size for all studies was n = 1266.

Table 4.1. Table summarizing the results of changes in HbA1c from the eleven dietary interventions included in the systematic review

First author, year of publication, location	**Participants (mean age in years)**	**Mean HbA1c (%) at baseline**	**Intervention (n per arm)**	**Composition of prescribed diets**	**Mean (mean± SD[a]) weight loss (kg)**	**Mean (mean ± SD[a]) decrease in HbA1c (%)**	**Duration**	**Attrition rate**	**Medication**	**Conclusion**
Guldbrand 2012 [18] Sweden	61 overweight and obese men and women with type 2 diabetes, (62.7)	7.35	Low Fat Diet (31) vs. Low Carbohydrate Diet (30)	Low fat diet: *55-60% carbohydrate, 10-15% protein, 30% fat* Low carbohydrate diet: *20% carbohydrate, 30% protein, 50% fat*	2.97 vs. 2.34 (P=0.33)	-0.2 vs. 0 No significant difference between groups (P=0.76)	2 years	9.7 % in LFD group and 13.3% in LCD	Authors reported that at 6 months there was a statistically significant difference in mean insulin dose in favour of the LCD (P = 0.046)	No significant difference between dietary interventions in improving HbA1c

Brehm 2009 [19] United States	124 overweight and obese men and women with type 2 diabetes (56.5)	7.3	High Monounsaturated fatty acid (MUFA) diet (43) vs. High Carbohydrate (CHO) diet (52)	MUFA: *45% carbohydrate, 15% protein, 40% fat (20% MUFA)* CHO: *60% carbohydrate, 15% protein, 25% fat*	4.0 ± 0.8 vs. 3.8 ±0.6 (P=0.867)	0 vs. -0.1 Authors stated no significant difference between groups (No P-value reported)	12 months	31% for the MUFA group and 16% for the high CHO group	Authors reported a lack of available information about participant's drug usage. Only information on 32 participants' drug use was available, which showed no systematic differences between diet groups. Therefore no adjustments were made for glucose lowering medication	No significant difference between dietary interventions in improving HbA1c

Fabricatore 2011 [9] United States	79 obese men and women with type 2 diabetes (52.7)	6.8	Low Fat (39) vs Low-Glycaemic Load (GL) (40)	Low fat: *<30% fat* Low-GL: *3 or less servings of moderate-GL and 1 or less serving of high-GL foods per day*	4.5 ±0.34 vs. 6.4 ± 0.52 (P=0.28)	0.1 ±0.0012 vs. 0.8 ± 0.0104 Significant difference between groups (P=0.01)	40 weeks	36.7%	Authors stated that changes in HbA1c were adjusted for medication use. Percentage of participants who increased, decreased or did not change their diabetic medication regime did not differ between the groups at week 20 (P = 0.51) or at week 40 (P = 0.70)	Low GL appears to be more effective in reducing HbA1c compared with a the Low Fat diet

Elhayany 2009 [12] Israel	259 overweight and obese men and women with type 2 diabetes (55.0)	8.3	Low-Carbohydrate Mediterranean diet (61) vs. Traditional Mediterranean diet (63) vs. American Diabetes Association diet (55)	LCM: *35% low-GI carbohydrate, 15-20% protein, 45% fat rich in MUFAs* TM: *50-55% low-GI carbohydrate, 15-20% protein, 30% fat rich in MUFAs* ADA: *50-55% carbohydrate, 15-20% protein, 30% fat*	10.1 vs. 7.4 vs. 7.7 Authors stated no significant difference between groups (No P-value reported)	2.0 vs. 1.8 vs. 1.6 Significant difference between diets (P=0.021), LCM different than ADA, TMD different than ADA	12 months	30.9%	Authors do not mention baseline medication characteristics or any changes in glucose lowering medication use during the course of the intervention	LCM diet appears to be more effective in reducing HbA1c compared with a TM and ADA diets

Barnard 2009 [13] United States	99 obese men and women with type 2 diabetes (55.7)	7.99	Low Fat Vegan diet (49) vs. American Diabetes Association diet (50)	Low fat vegan diet: *75% carbohydrates, 15% protein, 10% fat* ADA: *60-70% carbohydrates, 15-20% protein and monounsaturated fats*	4.4 ±0.9 vs. 3.0 ±0.8 (P=0.25)	0.34 ±0.19 vs. 0.14 ±0.17 No significant difference between groups (P=0.43) 0.4% vs. 0.01% (P = 0.03) when adjusted for medication	74 weeks	18.4% for the Vegan group 14% for the ADA group	Net 74 week dosages were reduced in 35 % participants in vegan group and 20% of those in the ADA group, and were increased in 14% of vegan group and 24% of conventional group	Once data is adjusted for medication use, there appears to be a significant benefit in the low fat vegan diet in decreasing HbA1c compared to the ADA diet

Esposito 2009 [10] Italy	215 overweight men and women with type 2 diabetes (52.2)	7.73	Low Carbohydrate Mediterranean diet (107) vs. Low Fat diet (108)	LCMD: *50% carbohydrate, 20% protein, no less than 30% fat* LFD: *No more than 30% fat with no more than 10% saturated fat*	3.8 ±2 vs. 3.2 ± 1.9 Authors stated no significant difference between groups (No P-value reported)	0.9±0.6 vs. 0.5 ±0.4 Authors stated significant differences between groups (No P-value reported)	4 years	9.3%	After 4 years 44% of participants in the LCMD and 70% of those in the low-fat diet group required treatment (absolute difference, -26.0 percentage points [95% CI, 0.51 to 0.86], hazard ratio adjusted for weight change, 0.70 [CI, 0.59 TO 0.90]; P < 0.001).	LCMD appears to be more effective in reducing HbA1c compared to a LFD with less need for glucose lowering medication

Pedersen 2014 [14] Australia	76 overweight men and women with type 2 diabetes (60.9)	7.3	High Protein Diet (21) vs. Standard Protein Diet (24)	HPD: *40% carbohydrate, 30% protein, 30% fat* SPD: *50% carbohydrate, 20% protein, 30% fat*	9.7 ±2.9 vs. 6.6 ±1.4 (P=0.32)	0.4 vs. 0.3 No significant difference between groups (P=0.29)	12 months	40.8%	Did not account for changes in medication, although authors stated that 4 volunteers managed their diabetes with diet alone, and all others treated with oral medication and/or insulin	No significant difference between dietary interventions in improving HbA1c

Iqbal 2010 [15] US	144 obese men and women with type 2 diabetes (59.4)	7.75	Low Carbohydrate (40) vs. Low Fat diet (28)	Low carbohydrate: *< 30g/day carbohydrate* Low fat: *< or equal to 30% of energy for fat with < 7% of energy from saturated fat*	1.5 vs. 0.2 (P=0.147)	0.1 vs. 0.2 No significant difference between groups (No P-value reported)	24 months	60% in the low carbohydrate group and 46% in the low fat group	Authors stated that many participants were unable to provide information regarding changes to medication or dosages and therefore the effects of glucose lowering medication was not adjusted for.	No significant difference between dietary interventions in improving HbA1c

Ma 2008 [11] United States	40 overweight and obese men and women with type 2 diabetes (53.5)	8.42	American Diabetes Association diet (21) vs. Low Glycaemic Index (GI) diet (19)	ADA: *60-70% carbohydrates, 15-20% protein and 30% fats* Low-GI: *Participants given goals to reduce daily dietary GI score to 55*	0.80 vs. 1.32 (P=0.89)	0.43 vs. 0.35 No significant difference between groups (P=0.88)	12 months	10% for the ADA group and 10% for the Low GI group	Participants in the Low GI group were less likely to add or increase dosage of glucose lowering medications (odds ratio 0.26, P = 0.01)	No significant difference between dietary interventions in improving HbA1c

Milne 1994 [16] New Zealand	70 overweight and obese men and women with type 2 diabetes (58.5)	10.0 ± 0.35	Weight Management diet (21) vs. High-Carbohydrate/Fiber diet (21) vs. Modified Lipid diet (22)	Weight management diet: *Restrict extrinsic simple sugars and energy dense foods, no advice for macronutrient contribution* High carbohydrate/fiber: *55% carbohydrate, 15% protein, 30% fat, 30g or more dietary fiber per day* Modified lipid diet: *45% carbohydrate, 19% protein, 36% fat*	-1.5 vs. 1.0 vs. 0.1 Authors stated no significant difference between groups (No P-value reported)	0.1 vs. 0.1 vs. 0.2 Authors stated no significant difference between groups (No P-value reported)	18 months	8.6%	Authors state that 52.3 % of the weight management group, 57.1% of the high carbohydrate/fiber group and 50% of the modified lipid diet were on glucose lowering medication at baseline. However there is no mention of medication adjustments being made throughout the study	No significant difference between dietary interventions in improving HbA1c

Larsen 2011 [17] Australia	99 overweight and obese men and women with type 2 diabetes (59.2)	7.84	High Protein (53) vs. High Carbohydrate (46)	High protein: *40% carbohydrate, 30% protein, 30% fat* High carbohydrate: *55% carbohydrate, 15% protein, 30% fat*	2.23 vs. 2.17 (P=0.78)	0.23 vs. 0.28 No significant difference between groups (P=0.44)	12 months	9.2 % High Protein group vs. 4.2 % High carbohydrate	Authors reported a significant reduction in the requirement for glucose lowering medication in the HP group compared with the HC group at 3 months (P =0.03) although the difference was no longer significant at 12 months (P = 0.05). However authors stated that that there were not significant differences in the decrease in HbA1c between groups when values were adjusted for changes in medication	No significant difference between dietary interventions in improving HbA1c

[a] Standard deviation (SD) values are reported for mean weight loss and mean reduction HbA1c where available

American Diabetes Association (ADA)

Carbohydrate (CHO)

High Protein Diet (HPD)

Low Carbohydrate Diet (LCD)

Low Carbohydrate Mediterranean (LCM)

Low Carbohydrate Mediterranean Diet (LCMD)

Low Fat Diet (LFD)

Low Glycaemic Load (Low GL)

Monounsaturated fatty acid (MUFA)

Table 4.2. Table summarizing the changes in dietary intake at baseline and at end point of intervention

First author, year of publication (reference)	**Intervention (n per arm)**	**Dietary assessment tool used**	**Composition of prescribed diet**	**Composition of diet consumed [a]**	**Comments**
Guldbrand 2012 [18]	Low Fat Diet (31) vs. Low Carbohydrate Diet (30)	3-day food record	Low fat diet: *55-60% carbohydrate, 10-15% protein, 30% fat* Low carbohydrate diet: *20% carbohydrate, 30% protein, 50% fat*	Low fat diet: *47% carbohydrate, 20% protein, 31% fat* Low carbohydrate diet: *31% carbohydrate, 24% protein, 44% fat*	There was a significant between group differences for the percentage of energy from carbohydrates, fat ($P < 0.001$) and for protein ($P = 0.009$)
Brehm 2009 [19]	High Monounsaturated fatty acid (MUFA) diet (43) vs. High Carbohydrate (CHO) diet (52)	3-day food record	MUFA: *45% carbohydrate, 15% protein, 40% fat (20% MUFA)* CHO: *60% carbohydrate, 15% protein, 25% fat*	MUFA: *46% carbohydrate, 16% protein, 38% fat (20% MUFA)* CHO: *54% carbohydrate, 18% protein, 28% fat*	The high MUFA diet group consumed significantly more total fat, PUFA and MUFA than the high carbohydrate group ($p< 0.001$)

Fabricatore 2011 [9]	Low Fat (39) vs. Low- Glycaemic Load (GL) (40)	3-day food record	Low fat: *<30% fat* Low-GL: *3 or less servings of moderate-GL and 1 or less serving of high-GL foods per day*	Low fat: *32.9% fat* *GL 121.3* Low-GL: *39.8% fat* *GL 88.6*	Reductions in energy from fat were significantly greater among those in the low-fat group at week 40 ($P \leq 0.01$) Low-GL group had significantly greater reductions in energy from carbohydrate ($P \leq 0.01$) and significantly greater reductions in dietary GI ($P \leq 0.003$) and GL ($P \leq 0.03$) Changes on other measured dietary variable was not significantly different between groups
Elhayany 2009 [12]	Low-Carbohydrate Mediterranean (61) vs. Traditional Mediterranean (63) vs. American Diabetes Association diet (55)	Food frequency questionnaire and 24 h recall	LCM: *35% low-GI carbohydrate, 15-20% protein, 45% fat rich in MUFAs* TM: *50-55% low-GI carbohydrate, 15-20% protein, 30% fat rich in MUFAs* ADA: *50-55% carbohydrate, 15-20% protein, 30% fat*	No breakdown of the actual macronutrient content which was consumed during the intervention	Statistically significant trend in percentage of energy from PUFA intake, highest 12.9% for LCM, to 11.5% in TM, and lowest in ADA 11.2% ($p = 0.002$) Same significant trend observed for MUFA fat intake (14.6, 12.8, and 12.6% for LCM, TM and ADA, respectively, $p < 0.001$). Opposite trend seen for % of energy from carbohydrate, highest for ADA 45.4% then 45.2% for TM and lowest for the LCM with 41.9 % ($p = 0.011$)

Barnard 2009 [13]	Low Fat Vegan diet (49) vs. American Diabetes Association diet (50)	3-day food record	Low fat vegan diet: *75% carbohydrates, 15% protein, 10% fat* ADA: *60-70% carbohydrates, 15-20% protein and 30% fats*	Low fat vegan diet: *66.3% carbohydrates, 14.8% protein, 22.3% fat* ADA: *46.5% carbohydrates, 21.14% protein and 33.7%*	At the end point of intervention, dietary adherence was met by 51% of participants in the vegan group and 48% of those in the ADA group
Esposito 2009 [10]	Low Carbohydrate Mediterranean diet (107) vs. Low Fat diet (108)	Food diary records	LCMD: *50% carbohydrate, 20% protein, no less than 30% fat* LFD: *No more than 30% fat with no more than 10% saturated fat*	LCMD: *44.2% carbohydrate, 18% protein, 39.1% fat, 10% saturated fat, 17.6% monounsaturated fat* LFD: *51.8% carbohydrate, 17.9% protein, 29.4% fat, 9.4% saturated fat, 12.4% monounsaturated fat*	Between group differences in % CHO and MUFA significantly different throughout the trial
Pedersen 2014 [14]	High Protein Diet (21) vs. Standard Protein Diet (24)	Food frequency questionnaire and 24 h urea excretion	HPD: *40% carbohydrate, 30% protein, 30% fat* SPD: *50% carbohydrate, 20% protein, 30% fat*	HPD: *39.2% carbohydrate, 26% protein, 34.8% fat* SPD: *44.8% carbohydrate, 21.1% protein, 34.0% fat*	At 12 months adjusted urea excretion was significantly different between groups (519 +/- 39 for HPD and 456 +/- 25 for the SPD group, P = 0.04) indicating compliance to protein prescription

Iqbal 2010 [15]	Low Carbohydrate (40) vs. Low Fat diet (28)	3-day food record	Low carbohydrate: < 30g/day carbohydrate Low fat: < or equal to 30% of energy for fat with < 7% of energy from saturated fat	Low carbohydrate: 192.8 g/day carbohydrate Low fat: 33.6% of energy from fat	Authors concluded that macronutrient intake was not significantly different between groups at any point. Authors concluded that both groups failed to achieve dietary targets
Ma 2008 [11]	American Diabetes Association diet (21) vs. Low Glycaemic Index (GI) diet (19)	7-day dietary recall	ADA: *60-70% carbohydrates, 15-20% protein and 30% fats* Low-GI: *Participants given goals to reduce daily dietary GI score to 55*	ADA: *38% carbohydrates, 80 GI, 20% protein, 43% fat* Low-GI: Daily GI score of 76 *37% carbohydrates, 76 GI, 20% protein, 43% fat*	Differences in dietary GI did not reach significance until 12 months (P = 0.07), However GL was significantly lower in the low –GI diet at 6 months (97 vs. 141, P = 0.02)

Milne 1994 [16]	Weight Management diet (21) vs. High-Carbohydrate/Fiber diet (21) vs. Modified Lipid diet (22)	24 h recall	Weight management diet: *Restrict extrinsic simple sugars and energy dense foods, no advice for macronutrient contribution* High carbohydrate/fiber: *55% carbohydrate, 15% protein, 30% fat, 30g or more dietary fiber per day* Modified lipid diet: *45% carbohydrate, 19% protein, 36% fat*	Weight management diet: *47.6% carbohydrate, 18.8%, 33.6%, 17.3g dietary fiber per day* High carbohydrate/fiber: *46.6% carbohydrate, 21.0% protein, 32.4% fat, 21.1 dietary fiber per day* Modified lipid diet: *46.4% carbohydrate, 19.7% protein, 33.9% fat*	Authors concluded that almost none of the participants succeeded in achieving currently recommended intakes of either CHO or unsaturated fat.
Larsen 2011 [17]	High Protein (53) vs. High Carbohydrate (46)	3-day food record	High protein: *40% carbohydrate, 30% protein, 30% fat* High carbohydrate: *55% carbohydrate, 15% protein, 30% fat*	High protein: *41.8% carbohydrate, 26.5% protein, 30.7% fat* High carbohydrate: *48.2% carbohydrate, 18.9% protein, 32.0% fat*	Significant differences between groups in the quantities of carbohydrates and protein consumed

[a] values are from reported dietary intakes at the end point of intervention

American Diabetes Association (ADA)

Carbohydrate (CHO)

High Protein Diet (HPD)

Low Carbohydrate Diet (LCD)

Low Carbohydrate Mediterranean (LCM)

Low Carbohydrate Mediterranean Diet (LCMD)

Low Fat Diet (LFD)

Low Glycaemic Load (Low GL)

Monounsaturated fatty acid (MUFA)

Standard Protein Diet (SPD)

Traditional Mediterranean (TM)

4.4.3 Interventions-general overview

A wide range of dietary interventions were examined, including low-fat vegan, ADA, low GI, high protein diet, standard protein diet, low fat diet, low carbohydrate, low GL, low-carbohydrate Mediterranean, traditional Mediterranean, high- carbohydrate/fibre and a modified lipid diet. Of the 11 studies included, 2 studies compared 3 different dietary interventions whereas the other 9 studies compared 2 dietary interventions. In total there were 24 individual comparators.

4.4.4 Interventions showing a positive effect

From the 11 studies, 9 demonstrated a positive effect of dietary intervention on improving HbA1c values at the end-point of intervention (9,10,11,12,13,14,15,16,17). However, 5 of these studies did not report statistically significant differences between dietary arms in the reductions in HbA1c values (11, 14,15,16,17), and so do not appear to support the use of one dietary intervention over another, as comparators had similar positive effects on glycaemic control.

4.4.5 Interventions showing no effect

Out of the 11 studies, 2 reported that the prescribed dietary interventions failed to decrease HbA1c levels (18,19). Guldbrand et al. 2012 (18) compared a low-carbohydrate diet to a low-fat diet, and despite both groups experiencing significant weight loss, there were no significant improvements in HbA1c at the end point of either dietary intervention. However, the authors stated that at 6 months into the intervention, there was a statistically significant difference in mean insulin dose in favour of the low-carbohydrate diet (P = 0.046). Brehm et al. 2009 [19] compared a predominantly mono-unsaturated fatty acid (MUFA) diet to a high carbohydrate (CHO) diet, and again despite reductions in body weight over 12 months of 4.0 $\pm$ 0.8 kg vs. 3.8 $\pm$ 0.6 kg, respectively, the interventions failed to be effective in improving glycemic control, with non-significant mean changes in HbA1c levels for both groups. It is important to note that authors reported a lack of information about changes that were made to the type and dosage of glucose lowering medication. Therefore it appears that no adjustments were made to account for the effects of medication on glycaemic control. This lack of ability to take into consideration the effect of medication on glycaemic control is a potential limitation.

4.4.6 Interventions showing significant differences between dietary groups

Only 4 studies reported a significant difference in HbA1c between different dietary interventions despite a non-significant difference in weight loss (Table 4.1) (8,9,11,12).
Fabricatore et al. 2011 [9] compared a low-fat diet to a low-GL diet, with the participants in the low-GL group experiencing a significantly greater reduction in HbA1c compared to those in the low-fat diet, 0.8 $\pm$ 0.0104 % vs. 0.1 $\pm$ 0.0012 %, respectively (P=0.01). Authors reported that the values presented were adjusted to account for changes in glucose lowering medication, and that the percentage of participants who increased, decreased or did not change their medication protocol was not statistically different between groups at week 20 (P = 0.51) or at week 40 (P = 0.70). Therefore this study appears to demonstrate a benefit of a low-GL diet over a low-fat diet in improving HbA1C levels.

Elhayany et al. 2009 [(12)] conducted a three-arm intervention comparing a low-carbohydrate Mediterranean (LCM) diet, a traditional Mediterranean (TM) diet, and the 2003 ADA diet. All 3 interventions were successful in reducing weight and improving HbA1c levels. Participants in the LCM diet experienced the greatest reduction in HbA1c, 2.0% compared to 1.8% in the TM group and 1.6% in the ADA group (p=0.021). However it is important to view these results with caution, as authors do not report baseline medication characteristics of the participants or any changes in glucose lowering medication throughout the course of the intervention. Therefore values have not been adjusted for medication, and the lack of information available regarding type and dosage of glucose lowering medication makes it impossible to confirm that it was the LCM diet itself that was more effective in reducing HbA1c, or if the changes observed may have been a result of differences in medication use and dosage between the 3 intervention groups.

Barnard et al. 2009 [(13)] compared a low-fat vegan diet to an ADA diet, with results showing a greater mean reduction in HbA1c for patients on the low-fat vegan diet. Authors reported a mean decrease of 0.4% for the low-fat vegan group and 0.1% decrease for the ADA group once adjustments were made for changes in medication.

Esposito et al. 2009 [(10)] compared a LCM diet to a low-fat diet. The LCM diet led to a significantly greater reduction in Hba1c, with a mean decrease of 0.9% compared to the 0.5% achieved in the low-fat diet group. This study appears to show a benefit of using a LCM diet over a low-fat diet in reducing Hba1C levels beyond the effects of weight loss. Two of the strengths of this study are that all participants were newly diagnosed with T2DM and were not taking any form of glucose lowering medication. The primary outcome of the study was commencement of medication, which itself followed a strict protocol. As shown in table 4.1, the LCM diet resulted in a significantly lower HbA1c value with less need for glucose lowering medication when compared with the LFD. However due to the nature of the study design, physicians were not blinded to the intervention groups in order to administer medication, which is a limitation.

4.4.7 Limitations in adherence to prescribed diets

One issue common to most studies was the lack of compliance to the prescribed dietary intervention. As shown in Table 4.2, apart from Pedersen et al. 2014 [(14)] who used 24-h urea excretion method for assessing adherence to prescribed protein intakes, the remaining 10 studies relied on self-report dietary intake data. Differences in prescribed versus reported diets are apparent when comparisons are made with the macronutrient targets set at baseline to those that were reported at the end point of intervention (Table 4.2). Pedersen et al. 2014 [(14)] reported that adjusted urea excretion was significantly different between groups (519 $\pm$ 39 for High Protein Diet and 456 $\pm$ 25 for the Standard Protein Diet group, P = 0.04), indicating compliance to the protein prescription. In contrast, Iqbal et al. 2010 (14) reported no significant difference in macronutrient intake between groups at any point during the intervention. In this study the participants in the low-carbohydrate group were prescribed a diet with less than 30 g of carbohydrates per day; however data from 3-day food diaries revealed a mean carbohydrate intake of 192.8 g per day. Similarly, Barnard et al. 2009 [(13)] reported that at the end point of intervention, dietary adherence was met by only 51% of those in the low-fat vegan group and 48% of those in the ADA group.

4.5 Discussion

The results of this systematic review indicate that only four out of the eleven trials demonstrated a benefit of one particular dietary intervention over another. These diets were low-GL, LCM, and low-fat vegan. Therefore it appears that these diets may have a beneficial effect on HbA1c independent of weight loss. However there are two major limitations within most of these studies that could have substantially affected reported results: lack of reporting and controlling for medication use and change, and poor compliance to the dietary intervention being studied.

Elhayany et al [12] demonstrated that the LCMD was more effective than the TMD and the ADA diet in reducing HbA1c. However this study lacked any control for the effects of glucose lowering medication, with no information available about baseline medication or any changes to medication occurring during the trial. Therefore, we cannot be certain whether the effects on the outcome measures were due to the dietary intervention or due to effects of glucose lowering medication.

The 3 interventions which show promise appear to be Fabricatore et al. 2011 [15], who demonstrated the benefit of low-GL diet over a low fat diet; Barnard et al, [13] who demonstrated a potential benefit of a low-fat vegan diet compared with the ADA diet, and Esposito et al, [10] who show a benefit of using a LCM diet over a low-fat diet. In contrast to Elhayany et al. [12] these three studies reported how changes in glucose lowering medication were managed and accounted for throughout the interventions. Furthermore both Barnard et al. [13] and Esposito et al. [10] reported that HbA1c values were significantly reduced, with less need for glucose lowering medication in the low-fat vegan and LCM dietary groups. Fabricatore and colleagues [15] demonstrated a benefit of using a low-GL diet compared to a low-fat diet; however, a limitation of this intervention was the high attrition rate of 36.7%.

Although the mechanisms leading to enhanced glycaemic control in these studies were not examined, existing research may help explain their findings. One potential mechanism for the effectiveness of a low –fat vegan diet is its high dietary fibber content. By the end of the 74-week intervention, participants in the low-fat vegan group were consuming a significantly greater amount of dietary fibber than those in the ADA group (21.7 $\pm$ 1.2 g/1000 kcal vs. 13.4 $\pm$ 0.8). Both Post et al. 2012 [20] and Silva et al. 2013 [21] conducted meta-analyses demonstrating the benefits of increasing fibber intakes and improved glycaemic control in patients with T2DM. Although these meta-analyses did not control for energy consumption, they do highlight the importance of dietary fibber in diabetes management. This is of importance when considering the effects of dietary approaches such as low-fat vegan or Mediterranean diets, as dietary fibber intakes tend to increase when consuming these diets, and as such any observed benefits on glycaemic control may potentially be due to increased fibber consumption.

A component of the Mediterranean diet that has been highlighted as a possible mechanism for its benefit in optimizing glycaemic control is the increased intake of monounsaturated fatty acids (MUFAs). Esposito et al. 2009 [10] reported a significant increase in the percentage of energy from MUFAs in participants consuming the LCMD compared with the low fat diet (LFD). Paniangua et al. 2007 [23] conducted a prospective crossover study on 11 insulin resistant participants, each spending 28 days consuming a diet high in saturated fat, a diet high in monounsaturated fat and a diet high in carbohydrates. The MUFA-rich diet improved insulin sensitivity, and lowered insulin resistance (HOMA-IR) to a greater extent compared with the high-saturated fat and the high carbohydrate diets (2.32 ± 0.3, 2.74 ± 0.4, 2.52 ± 0.4, respectively, $p < 0.01$). The high-MUFA diet also increased glucagon-like peptide-1 (GLP-1) more than the carbohydrate-rich diet. The diets were designed to ensure weight maintenance, with no changes in patients' body weights reported. Therefore this study demonstrated a potential effect of MUFA in improve insulin sensitivity, possibly via increased GLP-1 levels, independent of weight change.

The current systematic review does not fully support the findings of the previous systematic review conducted by Ajala et al. 2013 [(5)], as our findings do not support any benefit of consuming low-carbohydrate or high protein diets over another dietary intervention. Similar to Ajala and colleagues, our findings suggest a potential benefit of a Mediterranean-style diet. Three trials were included in their analysis, 2 of which were included in the current systematic review (Elhayany et al. 2010 [12], Esposito et al. 2009 [10]), with the third (Toobert et al. 2003 [24]) not meeting the inclusion criteria of the current systematic review as weight loss between groups was statistically significantly different. In addition, it is important to note that in the Toobert et al. 2003 [(24)] study, participants randomized to the MLP (Mediterranean Lifestyle Program) were not only given dietary advice to follow a Mediterranean diet, but were also given stress management classes, with exercise prescriptions involving both aerobic and strength training activity. Therefore the beneficial effects on HbA1c could have been due to many components of the intervention and not just dietary change. Therefore considering this study, along with Esposito et al. 2009 [(10)] and Elhayany et al. 2010 [(12)] (who did not take into account changes in medication) makes it difficult to assess the potential use of the meta analysis conducted by Ajala and colleagues in determining whether the Mediterranean diet is in fact superior to other dietary interventions.

Another limitation observed in the trials included in the current review was the variations in dietary compliance (See Table 4.2). The diet that was initially prescribed was not always consistent with what was consumed by the participants. Most studies did, however, manage to create sufficient differences in the consumption of certain macronutrients to allow researchers to distinguish significant differences between the dietary arms. Other researchers, such as Iqbal et al. 2010 (15) reported that there were no significant differences between macronutrient intakes any point during the trial, and thus it is not surprising that there was no difference in HbA1c levels between the groups.

Even though weight loss was not significantly different between any of the treatment arms in the included studies, there was a moderate positive correlation between weight loss and HbA1c (data not shown), indicating that higher weight loss was associated with greater improvements in HbA1c. This finding is not surprising, as weight loss is recognized as an integral component of treating patients with T2DM (25).

The main strength of this systematic review is that, to our knowledge, it is the first to attempt to control for the effects of weight loss between dietary treatment arms. An additional strength of this review was the use of a recognized tool for assessing the quality of the trials included. A limitation of our review was that due to the lack of a consistent control diet in the studies examined, we were not able to conduct a meta-analysis or provide quantitative data on the effect of the prescribed diets on changes in HbA1c. It is also not clear whether the participants included in the trials are generally representative of adults with type 2 diabetes.

In order to determine if one particular diet is superior in optimizing glycaemic control, a number of research design issues need to be applied to future research studies. Firstly, due to the nature of the effect of weight loss on glycaemic control, it is important to control for this in intervention studies. A well-designed study would include a comparison of dietary interventions that are isocaloric, and would measure and attempt to balance the energy expenditure of participants. If dietary arms are not isocaloric, it becomes difficult to distinguish the effects of different macronutrient compositions from the effects of a total caloric reduction. Another issue is the need to report medication use and dosage, and ideally control for changes in medication. From the 11 studies included in the current systematic review, only 6 reported some account of effects of medication. Of these, only Barnard et al. [13] and Esposito et al. [10] listed the protocols used for how changes in medication were handled. The effects of glucose lowering medication are clearly of major importance, and if the type and amounts patients are taking is not controlled for, then the effects of dietary interventions on outcome measures can only be speculative. If more trials address these limitations, it should become clearer if there is in fact a particular diet that is superior for treating overweight and obese patients with T2DM.

We conclude that there is currently insufficient evidence to state that a particular diet is superior to another for treating overweight and obese adults with T2DM. In line with current ADA guidelines, reducing total energy intake to promote weight loss should be the main strategy. As yet there still is not enough evidence to promote an ideal percentage of energy from carbohydrates, protein and fat. Although the Mediterranean, vegan and low GI diets appear to be promising, further research that controls for weight loss and the effects of diabetes medications in larger samples is needed.

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CHAPTER 5

DIETARY INTAKE AND FACTORS INFLUENCING EATING BEHAVIOURS IN OVERWEIGHT AND OBESE SOUTH ASIAN MEN LIVING IN THE UNITED KINGDOM- A MIXED METHOD STUDY

Note: This paper is currently under review as: ***Emadian, A.,*** *England, C.Y., and Thompson, J.L. Dietary intake and factors influencing eating behaviours in overweight and obese South Asian men living in the United Kingdom - A mixed method study. BMJ-Open.*

5.1 Abstract:

Abstract:

Objective:

South Asian men living in the UK are up to six times more likely to develop Type 2 Diabetes Mellitus (T2DM) than their white British counterparts. Despite this, very little is known about their current dietary intake patterns and eating behaviours. The objectives of this study were to assess diet, explore perceptions of T2DM, and investigate factors influencing eating behaviours in overweight/obese South Asian men.

Setting:

Community-based setting in the Greater London, UK area.

Participants:

South Asian men aged 18 to 64, with a BMI of over 23.0 kg/m^2, not previously diagnosed with T2DM.

Methods:

A cross-sectional mixed-methods design, including assessment of dietary intake using the UK Diet and Diabetes Questionnaire (UKDDQ; n=63), followed by semi-structured interviews in a purposive sample (n=36).

Results:

UKDDQ scores indicated 54% of participants had a 'healthy' diet with a mean sample score of 3.44±0.43 out of a maximum of 5. Oily fish consumption was low (1.84±1.85). Body weight was positively associated with a high-added sugar subscore (r=0.253, p=0.047), with 69.8% of the men having 'unhealthy' intakes of sugar-sweetened beverages. Cultural commitments (e.g.,

extended family and faith events), motivation and time were identified as key barriers to dietary change, with family support an important facilitator to making healthy dietary changes.

Conclusion:

Many of the areas of dietary improvement and factors affecting eating behaviours identified in this study are similar to those observed in the general UK population. Consumption of sugar-sweetened beverages in particular was high; given the association between their consumption and the risk of T2DM, this should be an area of primary focus for healthcare professionals. Nevertheless there are sociocultural factors unique to this population that need to be considered when designing culturally specific programs to reduce the development of T2DM in this high-risk population.

5.2 Introduction

South Asians are the largest ethnic minority in the United Kingdom (UK), representing 4% of the total population[1]. South Asians living in the UK have higher rates of Type 2 Diabetes (T2DM) compared to their white British counterparts, with T2DM up to six times more common in people of South Asian origin[2].

Although the exact cause of this increased risk for T2DM is not fully elucidated, it is theorised that a combination of genetic factors and the adoption of a 'Westernized' lifestyle, including adopting new dietary practices in place of previous traditional practices coupled with reductions in physical activity, are primary contributors[5, 6.] Despite the recognition of the critical role of dietary intake and eating behaviours in increasing T2DM risk, there is limited research examining this phenomenon in this population. Previous studies of South Asians have focused on measuring individual nutrient intakes as opposed to assessing diet as a whole[7]; others have focused only on children[8] or women[9]. The few studies involving men are relatively old[10] or in exclusively Muslim populations[11]. Thus, there is a substantial gap in the literature examining dietary intake in South Asian men currently living in the UK.

A recently published systematic review reported that there has been limited effectiveness in changing dietary practices in South Asian populations[12]. To effectively improve the diets of any population, it is vital to understand not only what individuals are eating, but also what key factors influence their dietary behaviours. Therefore to inform the development of effective, culturally appropriate interventions to change dietary intake amongst South Asian men, more research needs to be conducted to assess these behaviours and the factors influencing them.

The aim of this mixed-method study was to increase our understanding of dietary intake and related behaviours amongst overweight and obese South Asian men living in the UK by: 1) quantifying food intake and dietary behaviours using a newly validated food frequency questionnaire specifically developed for adults at risk for T2DM; and 2) using semi-structured interviews to explore the factors influencing eating behaviours.

5.3 Methods

5.3.1 Study Design and Participants

A cross-sectional mixed method study design was used to assess the dietary intake of a convenience sample of South Asian men at risk of developing T2DM (as defined by their overweight/obesity status and ethnicity), and to understand the key factors that influence their dietary choices and eating behaviours. Recruitment centred on building close ties with communities by visiting mosques, temples and community centres to discuss the research with community leaders. This was followed by advertising in local newsletters and running diabetes awareness days at the various temples to engage with members of the community.

Participants were eligible to take part if they were between the ages of 18-65yrs, had a body mass index (BMI) of ≥23.0 kg/m^2, and were fluent in English. From October 2015 to April 2016, sixty-three participants were recruited, with data collection conducted during a single visit, taking place either at the participant's home or in a private location at their place of work. All participants provided written consent to take part; the study was approved by the ethical review committee of the University of Birmingham (reference # ERN_15-0518).

During the data collection visit, demographic, anthropometric, resting blood pressure and dietary intake data were collected, followed by a semi-structured interview.

5.3.2 Demographic Data

Socio-demographic data were collected using a self-report questionnaire. Postcodes were used to generate an Index of Multiple Deprivation (IMD) rank, which is an indicator of level of deprivation and socio-economic status in England[13].

5.3.3 Anthropometric Data and Blood Pressure

Participants' height was measured (to the nearest 0.5 mm) using the Seca 213 Stadiometer, weight was measured (to the nearest 0.01kg) using the Seca 899 Digital Scale (Seca, Birmingham, UK) and BMI in kg/m^2 calculated. Waist circumference was measured at just above the umbilicus using a standard tape measure (to the nearest 0.5 cm). Resting blood pressure was recorded to the nearest mmHg using the Omron M10-It monitor (Omron, Milton Keynes, UK), after 5 minutes of seated rest. All measurements were taken and recorded three times, with mean of the two closest measures taken as the final value.

5.3.4 UK Diabetes and Diet Questionnaire

The UK Diabetes and Diet Questionnaire (UKDDQ) is a 25-item questionnaire designed to assess diet and dietary behaviours in adults with, or at risk for, T2DM. It has been shown to be a reliable and valid measure of diet when compared with 4-day food diaries[14]. An interviewer-administered version of the questionnaire (see supplementary data) was used to ensure accurate data entry and provide the opportunity to discuss both quantitative and qualitative aspects of dietary intake with participants.

5.3.5 Semi-Structured Interviews

A purposive sub-sample of 36 participants was invited to take part in individual, semi-structured interviews, conducted at the end of the data collection visit. Participants were purposively selected to provide maximum variation across age, ethnicity, faith, years living in the UK, and level of deprivation. Participants were interviewed until data saturation was reached, whereby no new data relevant to the research questions were being produced. An open-ended interview guide was used to inform the discussions, examining participants' perceptions of T2DM, the importance of dietary intake in preventing T2DM, barriers and facilitators to making dietary changes, and any sociocultural factors influencing dietary changes. The interview schedule was pilot tested with three South Asian men prior to commencing the study; further adjustments were made to the schedule throughout the data collection period using an iterative process. All interviews were audio-recorded and transcribed verbatim. All interviews were conducted in English.

5.4 Data Reduction and Statistical Analysis

5.4.1 Scoring and Coding of the UKDDQ

Of the 25 items on the questionnaire, 20 of the questionnaire items contributed to the overall score. Each of the 20 items has six categories for the participant to choose from, corresponding to the participant's frequency of consumption for that particular item. The researcher then scored the questionnaire by following the UKDDQ scoring protocol (*see appendix 3*) by providing a corresponding letter relating to the chosen answer for frequency of consumption ranging from an A (healthiest choice) to an F (least healthiest choice). Hence the final score shown to the participant revealed how many A's, B's, C's, D's, E's and F's the participant achieved out of the possible 20, informing them that A's and B's are 'healthy choices' C's and D's are 'less healthy choices' and E's and F's are 'unhealthy choices'. For the purpose of data analysis, the answers from each of the questionnaire items were re-coded into numerical values by applying the following codes A=5, B=4, C=3, D=2, E=1, F=0. The mean UKDDQ score for each individual was then calculated from the 20 questionnaire scores, giving a final score ranging from 0 to 5. Separate sub-scores were calculated by summing appropriate items for 'high-saturated fat' (full fat spread, high fat cheese, processed meat, savoury pastry and milk), 'high-fibre' (vegetables, fruit, high-fibre bread and high-fibre cereal) and 'high added sugar foods' (cakes and biscuits, confectionary, sweet drinks).

5.4.2 Quantitative data analysis

As the demographic data and the mean UKDDQ scores were not normally distributed, a two–step approach was used to normalise the data before statistical analysis was conducted[15], with step 1 including transforming the variable into a percentile rank, followed by a second step of applying an inverse normal transformation to the results derived from the first step. Descriptive analyses were conducted for all variables, including mean UKDDQ score and scores for each individual questionnaire item. Pearson's correlations were used to explore relationships between mean UKDDQ score and demographic variables. Spearman Rho correlations were used to explore the relationships between individual questionnaire items and demographic variables. Partial correlation analysis was used to determine the relationships between UKDDQ scores and demographic variables while controlling for country of birth and self-reported level of English literacy. A p value of <0.05 was interpreted as providing some evidence for a relationship between variables[16]. T-tests were used to test for any differences between key demographics of the full sample and the purposive sub-sample that participated in interviews, to determine if the sub-sample was reflective of the study sample. All statistical analyses were conducted using IBM SPSS statistical analysis software package (version 22.0).

5.4.3 Qualitative data analysis

Direct content analysis was used as the method for analysing the transcribed interviews. This approach is suitable for qualitative data analysis when there is already pre-existing research on the phenomenon being investigated[17]. As there is research on enhancing diet for health promotion, along with limited evidence exploring barriers to making dietary changes in South Asian men[18, 19], this qualitative analysis method was deemed most appropriate. The existing published research also steered the process for constructing the interview guide. Throughout the process of developing the interview guide, major themes and concepts developed, and these were then used as the main coding categories for analysis. All transcripts were initially coded using the main coding categories by AE, with a selection of transcripts being coded by a second researcher (CYE) to confirm agreement in coding. Data that did not map onto the initial categories were classified as a new category. Once the final coding categories were determined, the transcripts were re-examined and final coding categories agreed by all authors.

5.5 Results

5.5.1 Quantitative Results

All 63 participants completed the UKDDQ and were included in the analysis, with all 36 participants who were invited to be interviewed agreeing to take part (the sub-sample). The mean age of the sample was 44.83 ± 9.90, with a mean BMI of 28.06 ± 4.15 kg/m^2 (Table 5.1). T-tests found no differences between the full sample (n=63) and the sub-sample (n=36) for demographics, anthropometrics and mean UKDDQ score. Most participants were university educated (81%) and had excellent levels of self-reported English literacy (58.7%). The majority were Indian (87.3%) and Hindu (50.8%).

Table 5.1. Demographic and anthropometric characteristics for 63 South Asian men participating in the study.

Characteristic	Mean	S.D	Range
Age (years)	44.83	9.90	25-64
BMI (kg/m^2)	28.06	4.15	23.13-46.22
Weight (kg)	81.15	11.53	59.8-132.0
Height (cm)	170.84	6.11	157.70-185.90
Waist Circumference (cm)	99.73	10.44	83.50-136.0
Systolic Blood Pressure (mmHg)	128.22	15.19	99.00-184.00
Diastolic Blood Pressure (mmHg)	84.78	9.38	63.00-113.00
IMD Rank	16661.45	9470.80	2403-32823
Country of birth n (%)			
UK	10 (15.9)		
India	45 (71.4)		
Pakistan	1 (1.6)		
Bangladesh	7 (11.1)		
Ethnicity n (%)			
Indian	55 (87.3)		
Pakistani	1 (1.6)		
Bangladeshi	7 (11.1)		
Faith n (%)			
Hindu	32 (50.8)		
Sikh	18 (28.6)		
Muslim	9 (14.3)		
Hare Krishna	2 (3.2)		
Buddhist	2 (3.2)		
Education n (%)			

University/Higher Education	51(81)
College	6 (9.5)
Secondary School	4 (6.3)
Primary School	1 (1.6)
No Qualifications	1 (1.6)
Self-reported English literacy n (%)	
Excellent	37 (58.7)
Good	18 (28.6)
Fair	7 (11.1)
Poor	1 (1.6)
Self-reported Health n (%)	
Excellent	9 (14.3)
Good	37 (58.7)
Fair	16 (25.4)
Poor	1 (1.6)
Taking prescribed medication n (%)	
Yes	27 (42.9)
No	36 (57.1)
Taking BP medication n (%)	
Yes	16 (25.4)
No	47 (74.6)

Table 5.2 summarises the results from the UKDDQ, showing average total scores and individual questionnaire item scores. Mean total UKDDQ score for the full sample was 3.44± 0.43 with a median total UKDDQ score of 4 (interquartile range 3-4). Results showed that 54.0% of the

participants had a median score in the ‘healthy’ range (4 or more). Mean UKDDQ scores were not correlated to demographics or anthropometrics (data not shown), although individual questionnaire items and the ‘high added sugar foods’ subscale showed some evidence for a relationship (Table 5.3).

Partial correlation analysis revealed no significant correlations between the UKDDQ score and any of the demographic and anthropometric variables when controlling for country of birth and self-reported level of English literacy.

Table 5.2 Results from the UK Diabetes and Diet Questionnaire for 63 South Asian men participating in this study.

Questionnaire Item	Mean Score (S.D)	Median Score (IQR)	Equivalent Categorical Score	N (%) of participants achieving 'healthy' scores*
Vegetables[1]	3.65 (0.94)	4 (3-4)	1-2 times a day	45 (71.4)
Fruit[1]	3.51 (1.15)	4 (3-4)	1-2 times a day	43 (68.3)
Cakes and biscuits[2]	3.30 (1.29)	4 (3-4)	Once a week or less Often	36 (57.1)
Chocolate and sweets[2]	3.73 (1.31)	4 (3-5)	Once a week or less Often	45 (71.4)
Sweet drinks[2]	2.16 (1.75)	1 (1-4)	1-2 times a day	19 (30.2)
Full fat spread[2]	4.13 (1.09)	4 (4-5)	Once a week or less Often	49 (77.8)
High fat cheese[3]	3.49 (1.12)	3 (3-5)	Once a week	30 (47.6)
Processed meat[3]	4.00 (1.14)	5 (3-5)	Never or very rarely	37 (58.7)
Salted snacks[3]	2.48 (1.06)	2 (2-3)	2-5 times a week	11 (17.5)
Savoury pastries[3]	3.57 (0.91)	4 (3-4)	Less than once a week	33 (52.4)
Fast foods[3]	3.43 (1.00)	3 (3-4)	Once a week	29 (46.0)
Puddings[3]	3.75 (1.16)	4 (3-5)	Less than once a week	40 (63.5)
Alcohol[4]	4.21 (1.12)	5 (3-5)	Less than once a week	44 (69.8)
Oily fish[5]	1.84 (1.85)	2 (0-4)	Less than once a week	19 (30.2)
3-4 meals/day[6]	4.10 (1.54)	5 (4-5)	Every day	48 (76.2)
Breakfast[6]	4.27 (1.43)	5 (4-5)	Every day	50 (79.4)
High-fat/sugar snack[7]	2.86 (1.50)	3 (2-4)	Once a week	23 (36.5)
High fibre bread[8]	4.08 (1.32)	5 (4-5)	All of the time	48 (76.2)
High fibre cereal[8]	4.11 (1.80)	5 (4-5)	All of the time	52 (82.5)
Type of milk[9]	2.17 (1.78)	3 (0-3)	Semi-skimmed	9 (14.3)
UKDD Score	3.44 (0.43)	4 (3-4)		34 (54.0)

Abbreviations:

SD = Standard Deviation

IQR = Inter Quartile Range

UKDDQ = UK Diabetes and Diet Questionnaire

* 'Healthy' defined as a score of 4 or 5 (A or B)

[1] Never/very rarely=0; Once a week or less=1; 2-4 times a week=2; 5-6 times a week=3; 1-2 times a day= 4; 3 or more times a day=5

[2]Never/very rarely=5; Once a week or less=4; 2-4 times a week=3; 5-6 times a week=2; 1-2 times a day= 1; 3 or more times a day=0

[3]Never/very rarely=5; Less than once a week=4; Once a week=3; 2-5 times a week=3; Nearly every day or daily=1; Twice or more per day=0

[4]Never/very rarely=5; Less than once a week=5; Once a week=3; 2-5 times a week=3; Nearly every day or daily=1; Twice or more per day=0

[5]Never=0; Less than once a week=1; Once a week=4; Twice or more per week=5

[6] Never/very rarely=0; Less than once a week=1; Once a week=2; 2-4 times a week=3; 5-6 times a week=4; Every day=5

[7] Never/very rarely=5; Less than once a week=4; Once a week=3; 2-4 times a week=2; 5-6 times a week=1; Every day=0

[8] All of the time=5; Most of the time=4; About half the time=3; Less than half the time=1; Never=0; I did not eat bread/cereal=5

[9]Full fat=0; Semi-skimmed=3; Skimmed=5 Varies=2; Non- dairy milk=5; None=5

Table 5.3. Spearman's Rho correlations identifying relationships between demographic variables and scores for individual UKDDQ questions for 63 South Asian men participating in this study (only variables with some evidence for a relationship are shown).

	Vegetables	Cakes and biscuits	Full fat spread	Processed meat	Puddings	High fibre bread	Type of milk	High added sugar subscore[1]
Age	**0.344**** **(0.006)**	-0.008 (0.950)	-0.023 (0.855)	0.058 (0.652)	-0.119 (0.351)	-0.062 (0.632)	-0.001 (0.995)	-0.027 (0.832)
Weight	0.090 (0.481)	**0.262*** **(0.038)**	0.032 (0.800)	-0.077 (0.551)	0.051 (0.689)	0.075 (0.562)	-0.029 (0.822)	**0.252*** **(0.047)**
SBP	0.113 (0.377)	0.240 (0.058)	-0.092 (0.473)	0.108 (0.398)	**0.317*** **(0.011)**	-0.018 (0.886)	0.067 (0.604)	0.183 (0.151)
DBP	0.122 (0.343)	0.001 (0.991)	-0.102 (0.425)	**0.327**** **(0.009)**	0.244 (0.054)	0.103 (0.422)	-0.055 (0.670)	-0.060 (0.643)
IMD rank	0.178 (0.181)	0.024 (0.857)	**-0.279*** **(0.034)**	0.153 (0.252)	0.133 (0.321)	**0.299*** **(0.023)**	**0.289*** **(0.028)**	0.118 (0.379)

Abbreviations:

UKDDQ = UK Diabetes and Diet Questionnaire

BMI = Body Mass Index

WC = Waist Circumference

SBP = Systolic Blood Pressure

DBP = Diastolic Blood Pressure

IMD = Index of Multiple Deprivation

[1]High Added Sugar Subscore = Cakes and Biscuits + Chocolate and Sweets + Puddings + Sweet Drinks

* $p < 0.05$

* $p < 0.001$

Footnotes:

Table indicates that higher levels of deprivation were significantly correlated with higher intakes of full fat spread and lower intakes high fibre bread and low-fat milk. Pudding intake was significantly correlated with higher SBP.

5.5.2 Qualitative Results

Figure 5.1 illustrates the final coding matrix of the key factors affecting dietary behaviours as reported by participants in qualitative interviews. The following sections describe the findings, supported by representative quotes.

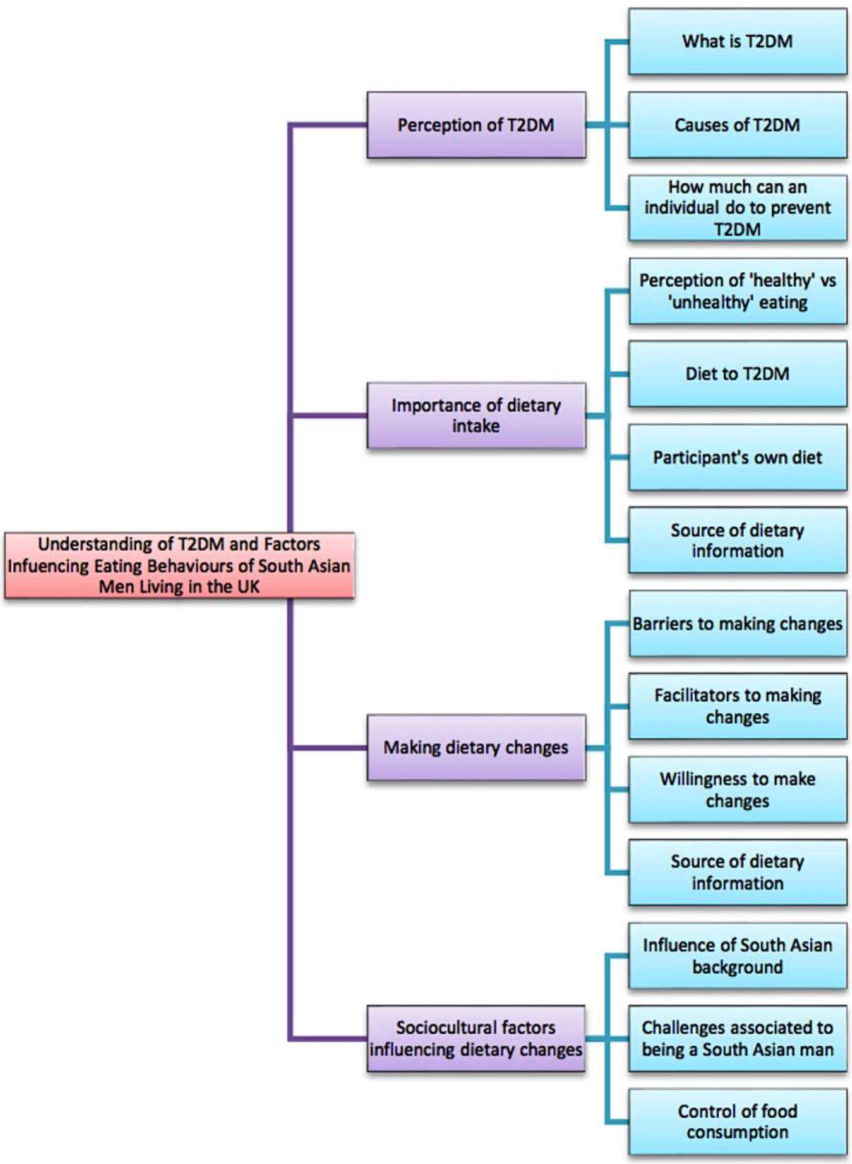

Figure 5.1. Diagram showing the final coding matrix identifying the key factors influencing dietary behaviours in 36 participants who participated in semi-structured qualitative interviews.

5.5.2.1 What is T2DM?

When asked about their perception of T2DM, most participants displayed some form of understanding as to what the condition was. However, 4 out of the 36 participants (11.1%) stated that they did not know. Of those who did have an understanding, most made reference to having high 'sugar' levels in the body:

'I think when you start getting the sugar issues or the problem where you have the high sugar in your blood. That is where your Type 2 diabetes starts'
(47y, Indian, Hindu, living in the UK for 16y.)

Participants also contextualised T2DM from their understanding of the symptoms relating to the condition:

'Yes, I think that diabetes affects vision. It affects, um, the, the mass around the stomach and possibly swelling at the feet as well'
(58y, Indian, Hindu, living in the UK for 54y)

Approximately one-third of participants mentioned they had an immediate relative who had T2DM, and therefore had seen the symptoms of the condition for themselves.

5.5.2.2 Causes of T2DM

The five risk factors for T2DM identified by participants included: diet, genetics, physical activity, sedentary time and body weight. Almost all mentioned diet to be the key risk factor, focusing on the effects of high sugar consumption:

'Sometimes eating too much sugar in your diet, and also it can be hereditary where even if you don't eat too much sugar you can probably have it as well.'
(33y, Indian, Hindu, living in the UK for 33y)

5.5.2.3 How much can an individual do to prevent T2DM?

All participants agreed to some extent that an individual could act to prevent developing T2DM. The combination of diet and exercise was perceived to be the best way to prevent T2DM:

'To prevent, right, is, ah, the best thing, that the healthy diet and the exercise, burning, so if you're burning calories which you're consuming, it's the right balance of it. If it is not balanced, then it can go to diabetes'
(46y, Indian, Sikh, living in the UK for 27y)

5.5.2.4 Perception of 'healthy' vs. 'unhealthy' eating and diet to prevent T2DM

In general participants were aware of general dietary guidelines. When asked what they considered to be 'healthy eating' most mentioned the benefits of reducing sugar and fat intake, along with increasing fruit and vegetable intake:

'Healthy eating is lots of fruits, vegetables, ah, leafy green vegetables, and ah, less of cakes and biscuits and crisps'

(41y, Indian, Hindu, living in the UK for 11y)

Others expanded further by considering the importance of portion control in a healthy diet:

'I mean, healthy eating is, err, you know, you eat whatever you like but, you know, you're in control. In control...err, in control the portions, err, where whatever you eat you can burn it off then you can eat anything you want, right'

(47y, Indian, Hindu, 15y)

In contrast, lack of portion control was identified as an important contributor to 'unhealthy eating':

'Unhealthy eating is, uh, I'd say, binge eating like, you know, eating a lot of takeaways and, uh, uh, there's not time to, you know, set time for your meals, no set portions and, literally all the junk food…'

(30y, Indian, Sikh, living in the UK for 5y)

5.5.2.5 Participant's own diet

Over 36% (13/26) of participants assumed that their diet was healthy, though most mentioned that there was room for improvement:

'My diet, I will say, is not as healthy as I would like it to be… I would like to control it or sort of cut it down.

5.5.2.6 Willingness to make changes

All 36 participants stated that they were willing to make positive dietary choices based on the suggestions given to them upon completing the UKDDQ.

5.5.2.7 Facilitators to making changes

Participants typically regarded confidence and intrinsic motivation as important facilitators to making change:

'Uh, I think, I have to be more confident. Self-determination I think and that's the most important thing'

(49y, Indian, Sikh, living in the UK for 30y)

Family support, particularly in relation to food choice and preparation, was an important theme, with wives having particular influence:

'I think what my wife cooks, I think her support is quite critical. Which is I think is true for all South Asians, or for that matter everybody I guess who's married, and whose food [consumption] is dependent on what their partner cooks'

(37y, Indian, Hindu, living in the UK for 5y

5.5.2.8 Barriers to making changes

A lack of motivation was the main theme most commonly mentioned as a barrier to making positive dietary changes:

'I am willing, it just comes down to laziness and having the motivation to stick to it. (....)…I'll do it [healthy eating] for two or three days and then they'll be a day when I'm really craving for sugar'

(33y, Indian, Hindu, living in the UK for 33y)

Time constraints, in particular related to work, were seen as a limiting factor in making dietary changes:

'It's the travelling and…the work related timing issues would make difficult for following the diet'

(47y, Indian, Hindu, 15y)

Cultural commitments emerged as an issue of particular importance when trying to make changes:

‘My factors I'd say uh, commitments as per, cultural commitments are concerned. You know, we [have] a lot of family events, ceremonies and stuff and then it becomes very hard for us to sort of get out of that. I mean, an example, was before and after the [his] wedding. Before [when] I was single and, could sort of escape and, you know, have my control of my diet, but once, you know, [you marry and] get into that routine where you might invite over someone else, guests, we do invitations, a lot of invitations, will go out for a lot of dinners or a lot of people coming around for dinners and that's that for like two or three times a week...we just literally lavish out in our eating and drinking’

(30y, Indian, Sikh, 5y)

5.5.2.9 Influence of South Asian background

The majority of men believed that their South Asian background has a significant effect on their dietary habits. The common perception by twenty of the men (55.5%) was that the typical South Asian diet was an unhealthy diet:

‘I think is South Asian food is, is, especially Indian food is really, really rich food’

(49y, Indian, Sikh, living in the UK for 30 y)

In relation to the context of the South Asian diet, the long-term habits of being accustomed to eating certain foods was something that many believed would be difficult to change:

'It's um, the nature of the food we eat. Someone had told me it is like, food is one thing which you never give up, you can change yourself, culturally or everywhere, that's the bit which is the hardest to give up'
(45y, Indian, Hindu, living in the UK for 11y)

Another major theme revolved around the impact of festivals and social events on the participant's diet, as illustrated in the following quotes:

'I think it is a big part, and also the type of food, ah, which gets given. So we had Diwali, which is one of the biggest festivals… it's now that I think about it, after having discussed with you, I'm struggling to find anything which would be healthy during that period. It's all very sweet, or deep fried, and would have a lot of fat and sugar. And…the festival lasts for I think, three or four days, but the festivities go on for a week or two, and you keep having that all. So that is fat or sugar enough, which you would eat, would normally have in the span of three months…
(41y, Indian, Hindu, 11 years living in the UK)

'We pig out on festivals so you should ask them to count the number of festivals they're on and occasions and there are a lot. So, for like 365 days you'll find, like, 100 days you're pigging out. And then... and that you probably consume, like, 5000 calories during that time. And they say, oh, it's just like a festival but, no, it's actually much, much more than what people think'

(34, Indian, Hindu, living in the UK for 18y)

Some also made reference to the belief that the differences in climate in the UK compared to the climate in South Asia plays a role in the increased risk of developing T2DM:

'So there, because, I mean, it's the hot weather, you consume, you go out, energy burning, sweating and everything, you... is all... most of the energy is burnt in sweating and... but in the cold countries, the problem is that there is no sweating, there's no heat coming out from your body, and everything dump inside, and our skin is blocked, so that cause more problems inside when you consume and you don't burn'

(47y, Indian, Sikh, living in the UK for 27y)

5.5.2.10 Challenges associated to being a South Asian man

The main theme that emerged was the lack of control South Asian men believed they had over their food preparation:

'Most men don't cook, um, most of the times their wives cook. Many of them [wives] work but many of them don't work... To the extent your wife is not working what tends to happen is they try to make the food taste nice because, you know, (....)which means high fat, high salt, high sugar'

(34, Indian, Hindu, living in the UK for 18y)

5.5.2.11 Control of food consumption

The majority of married men (28/29, or 96.6%) reported that their wives were primarily responsible for cooking at home, with only one married man reporting he is the main cook in the household. Additionally 78.6% (22/28) stated that their wives were predominantly responsible for doing the grocery shopping. Furthermore, some participants emphasised their preference for their wives to take responsibility, often believing that their wives were more informed to make better decisions when it came to food selection:

'It's normally my wife [who does the food shopping], but because she does it, it's actually controlled, because she's well and truly on top of it, not just because of my stroke, she has been… she has been doing these kind of things for the last ten years'
(45y, Indian, Hindu, living in the UK for 11y)

5.6 Discussion:

Our data illustrate that 54% of participants had a 'healthy' diet based on their total UKDDQ score. Oily fish consumption was low in South Asian men, with 30.2% of participants reporting 'healthy intakes'. Our data indicated that oily fish was being consumed 'less than once a week', which is comparable to data from the general adult population in England[20].

Participants' body weight was positively associated with a higher added sugar intake, which has been shown in previous studies in the general population[21, 22]. In particular, 69.8% of the men reported ‘unhealthy’ intakes of sugar-sweetened beverages. High consumption of sugar-sweetened beverages is commonly associated with increased risk of developing T2DM[23-26]. IMD rank was positively associated with both ‘High fibre bread’ and ‘Type of milk,’ indicating that participants who were less deprived were more likely to consume high fibre bread and skimmed/non-fat milk. Alternatively, participants that were more deprived were more likely to consume full fat spreads. This is supported by previous literature highlighting that higher socioeconomic status is often associated with healthier diets in the general population[27, 28].

The qualitative findings support existing evidence that participants’ understanding of T2DM is significantly shaped by the experiences of close friends and family who have the condition[29]. Results from a recent systematic review[30] suggest that South Asians have limited knowledge about the relationship between lifestyle and disease risks. Our results do not support this contention, as participants in the present study exhibited a good understanding of the main lifestyle-related risk factors contributing to the development of T2DM, with diet, body weight, physical activity and sedentary time identified. One explanation for this discrepancy may be the relatively high education level of our participants, in addition to their high level of self-reported English literacy that likely contributed to their relatively good knowledge about T2DM and related risk factors[31]. Also, the mean IMD rank of our participants places our sample in the middle (50.7%) of the rank of least to most deprived in England. This is in contrast to previous diet-related research conducted in South Asian adults, which has focused on participants from more deprived backgrounds[11,18,29,32]. Therefore our study provides insights into a segment of the South Asian population not previously represented in the literature.

Lack of time, motivation and cultural commitments were identified as the main barriers preventing South Asian men from making positive dietary changes. Lack of time and low motivation are also commonly reported barriers to dietary changes in White populations[34,35]. Existing research has previously highlighted the role of cultural commitments as a barrier to dietary change in South Asians[36, 37, 38]. The high frequency of these cultural events was a point reinforced by the men in our sample, and illustrates that the high frequency and lengthy duration of these events each year are major contributors to the over-consumption of less healthy foods.

Intrinsic motivation emerged as a key factor influencing dietary change, with almost all participants believing that it was up to them, first and foremost, to make changes. This finding is unique, as previous research in South Asian populations have reported that participants commonly express a sense of externalisation of responsibility, often citing 'fate' and 'God' as factors influencing the development of their health condition, and as a result, they exhibit a limited degree of personal responsibility[36, 37]. This theme of 'fatalism' was non-existent in our sample, with no participants externalising any responsibility for their health. Although some believed that they could only do so much to prevent T2DM, all believed that making changes to their lifestyles would have significant protective effects.

The perceived lack of control that men have over their food preparation was also a key finding from the present study. This supports previous research indicating that South Asian men are reliant on their wives/mothers to do the cooking at home[29]. It is of interest to note that during the administering of the UKDDQ, some men requested that their wives be present in order to confirm their frequency of consumption of certain food items, believing that their wives were more aware of their diets than they were.

The majority of men in the present studied stated the belief that being from a South Asian background affects their eating behaviours. A common theme was the role of cultural events, including religious events and weddings, which play an integral role in South Asian communities and families. These events are perceived as periods when men have little or no control over how food is prepared, and there is a distinct lack of healthy options available to them to choose from. This is widely supported by previous literature emphasising the impact of festivals and social events on dietary intake in South Asian adults[39, 40].

To our knowledge, this is the first mixed-methods study which has investigated dietary intake and eating behaviours in overweight/obese South Asian men living in the UK. Using a mixed methods approach is a strength of this study, as it provided a more in-depth understanding of what participants understand about T2DM, the foods they are eating, and the factors influencing eating behaviours than could be derived by using quantitative or qualitative methods in isolation. This was also the first study to have assessed diet in South Asian men living in the UK, using the newly developed and validated UKDDQ, which has been specifically designed for use with people at risk of, or with, T2DM living in the UK. Using this questionnaire allowed the researcher to focus on foods and behaviours that have been shown to be directly linked with weight loss and also served as a mechanism to stimulate rich conversations about diabetes prevention and healthy changes that could be made to their current dietary intake. The participants in the present study indicated that they felt this tool was appropriate and useful for

South Asians, as the questions focus on food groups and eating behaviours common across the range of ethnic groups living in the UK.

However, this study is not without limitations. The cross-sectional nature of this study provides only a snapshot of dietary intake in this sample. Due to the relatively small sample size, our findings may not be generalisable to the wider population of South Asian men living in the UK. Participants in our study were also highly educated, with 81% having a university degree, which may also limit the generalisability of our findings. However, 87.3% of the participants in our sample were Indian, with a further 71.4% being Indian immigrants. UK Indians are 1.5 times more likely to hold a degree than white British adults (Census 2011), furthermore 54% of UK Indian immigrants between the ages of 25-49 are university graduates (Census 2011). Therefore UK Indians are a highly educated minority group. Despite this many public health studies focusing on UK South Asians have often underrepresented Indians in their samples [18, 42, 43, 44, 45, 46], despite them being the most populous South Asian population in the UK. Therefore we believe this sample is representative of a significant portion of the UK South Asian population not previously represented in the literature.

This study revealed additional information about the unique socio-cultural challenges that overweight and obese South Asian men face when trying to make positive dietary changes, and as such healthcare professionals should be aware of these when implementing strategies to improve diet in this population. Further research using the UKDDQ in larger samples of South Asians and other populations in the UK will be needed, to allow for comprehensive comparisons to be made.

5.7 Conclusion:

Findings from this study illustrated that 54% of this sample of highly educated overweight and obese South Asian men living in the UK had ‘healthy’ diets. However from the dietary information gathered, diets were not too dissimilar to the general adult male population in England. Given that 69.8% had ‘unhealthy’ intakes of sugar-sweetened beverages, along with the previous data demonstrating the association between sugar-sweetened beverage consumption and T2DM, healthcare professionals should target reducing their consumption in UK South Asian men. In addition, there is scope to develop healthy eating advice targeting the frequency and duration of cultural events in which this population regularly engages.

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A MIXED-METHODS EXAMINATION OF PHYSICAL ACTIVTY AND SEDENTARY TIME IN OVERVEIGHT AND OBESE SOUTH ASIAN MEN LIVING IN THE UNITED KINGDOM

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6.1 Abstract

South Asian men living in the UK have higher rates of central obesity and Type 2 Diabetes Mellitus (T2DM) compared with their white British counterparts. Physical activity (PA) and sedentary time (ST) are important risk factors for the development of T2DM. The purpose of this study was to objectively measure PA, ST, and to explore the factors influencing these behaviours in this high-risk population. A mixed-methods cross-sectional research design was employed, including the quantification of PA and ST using the self-report International Physical Activity Questionnaire (IPAQ)-long form and accelerometry in overweight and obese UK South Asian men (n = 54), followed by semi-structured interviews in a purposive sub-sample to explore the factors influencing PA and ST (n = 31). Accelerometer-derived moderate-to-vigorous PA (MVPA) and ST were 298.9 ± 186.6 min/week and 551.4 ± 95.0 min/day, respectively. IPAQ-derived MVPA was significantly lower than accelerometer-derived MVPA ($p < 0.001$). IPAQ-derived ST was significantly higher than accelerometer-derived ST ($p < 0.001$). Lack of time and family commitments were identified as the main barriers to being more physically active, with group exercise identified as an important facilitator to being more active. A cultural norm of focusing on promoting education over sport participation during childhood was identified as an important factor influencing long- term PA behaviours. Work commitments and predominantly sedentary jobs were identified as the main barriers to reducing ST. Healthcare professionals and researchers need to consider the socio-cultural factors which affect PA engagement in overweight and obese South Asian men living in the UK, to ensure that advice and future interventions are tailored to address the needs of this population.

6.2 Background

Physical activity (PA), defined as any bodily movement produced by the skeletal muscles which expends energy [1], and sedentary time (ST), defined as any sitting or laying activities equating to less than or equal to 1.5 Metabolic Equivalent of Task (METS) [2], have both been established as individual risk factors for chronic diseases including obesity and Type 2 Diabetes Mellitus (T2DM) [1]. PA is highlighted as influential in the prevention and management of T2DM [3], with current guidelines recommending at least 150 min of moderate intensity PA and 75 min of vigorous intensity PA per week to promote general health and well-being [4,5]. In addition, epidemiological studies such as the Nurse's Health Study have highlighted the inverse relationship between ST and T2DM risk [6], with a meta-analysis concluding that the more time adults spent being sedentary, their odds of developing metabolic syndrome increased by 73% [7].

South Asians living in the UK have substantially higher rates of central obesity and T2DM as compared to their white British counterparts, with T2DM up to six times more common in people of South Asian origin [8]. Published self-report data suggest that South Asians and other minority groups consistently undertake less PA than the majority of the population in the UK [9,10]. Self-report has been the main method for measuring PA in most population-based studies [11], and for many countries, recorded trends in changes in PA are based on a long history of questionnaire-based assessment [4]. In recent years, technological advances and reductions in costs have led to an increase in objectively measured PA using accelerometers [12]. Accelerometers are easy to wear motion sensors, which can be used to collect data to estimate the time spent in moderate- to-vigorous PA (MVPA) to determine whether individuals are meeting the minimum requirements of 150 min of MVPA per week [13].

A mixed-methods systematic review of PA in South Asians found that South Asian women had lower levels of self-reported PA when compared to both South Asian men and white European populations, and a lack of knowledge about the relative benefits of being more active [14]. Studies focusing on measuring PA and ST in South Asian men are limited; therefore there is need for these behaviours to be quantified. To our knowledge, no studies have been published to date employing a mixed-method approach to quantitatively measure PA and ST and to explore the factors that influence PA and ST behaviours in this population.

This mixed-method study will begin to address this gap in the literature and contribute to our understanding of PA and ST amongst South Asian men living in the UK by: (1) quantifying PA and ST using both self-report and objectively measured methods; and (2) using semi-structured interviews to explore factors influencing PA and ST in a sample of overweight and obese South Asian men living in the UK.

6.3 Methods

6.3.1 Study Design and Participants

A cross-sectional, mixed-methods study design was employed. Recruitment was primarily carried out through networking with community leaders and local diabetes awareness groups, which in turn helped obtain entry to mosques, temples, and community centres in the Greater London area, where it became possible to engage with members about possible participation in the study.

Participants were eligible to participate if they were of self-reported South Asian origin, were between the ages of 18 to 65 years, had not previously been diagnosed with T2DM, had a body mass index (BMI) of over 23.0 kg/m^2 [15], and did not need assistance to walk or climb stairs. Written consent was obtained from all participants. All participants gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the University of Birmingham (reference number ERN_15-0518).

A total of 63 participants were recruited between October 2015 and April 2016. The study was conducted during two separate visits scheduled one week apart. Both visits were conducted either at the participant's home or a private location at the participant's place of work. During the first visit, demographic and anthropometric data were gathered, and blood pressure and handgrip strength were measured. Also, participants were given an accelerometer to wear for seven consecutive days. Accelerometers were collected approximately 8–10 days later during the second visit, where self- reported PA and ST were assessed in all participants, and a semi-structured interview was conducted in a purposive sub-sample, whereby participants were chosen and interviewed until data saturation had been reached.

6.3.2 Demographic Data

Socio-demographic data including age, country of birth, ethnicity, religion, marital status, number of children, number of years living in the UK, English literacy, level of education, use of medication, and current residential postcode were collected using a self-report questionnaire. Residential postcodes were used to determine an Index of Multiple Deprivation (IMD) rank for each participant, which is an indicator of social and material deprivation in the UK [16].

6.3.3 Anthropometric Data, Blood Pressure, and Handgrip Strength

Height was measured (to the nearest mm) using the Seca 213 Stadiometer (Seca, Birmingham, UK); weight was measured (to the nearest 0.01 kg) using the Seca 899 Digital Scale (Seca). BMI was calculated by dividing weight in kg by the square of height in metres. Waist circumference was measured with a standard tape measure, with the base of the tape placed at the top of the umbilicus (to the nearest 0.5 cm). Resting blood pressure was measured using an Omron M10-It monitor (to the nearest mmHg) (Omron, Milton Keynes, UK) following 5 min of seated rest. Handgrip strength (HGS) was assessed using a Jamar hand dynamometer (to the nearest Kg Force) (Jamar, Nottingham, UK), as a measure of physical function. All measurements were taken and recorded three times, with the mean of the two closest values used in the analyses.

6.3.4 Self-reported PA and ST

Self-reported total moderate-to-vigorous PA and ST were assessed using the self-administered version of the International Physical Activity Questionnaire (IPAQ)-long form [17]. The IPAQ-long form is a questionnaire used to estimate the time spent in PA and ST in adults aged between 18–65 years over a seven-day period and has been validated in over 12 countries [18]. The IPAQ-long form assesses PA and ST over five different domains—'work-related', 'transport', 'leisure time', 'domestic and garden', and 'time spent sitting'—and is therefore preferred over the IPAQ-short form for research purposes [17]. Self-reported duration (in minutes) and frequency (in days) across all five domains were then computed to produce an output for PA and ST. Based on the IPAQ protocol, the minutes per week (min/week) that were generated for PA were then multiplied by a metabolic equivalent of task (MET). METs are assigned to different forms of activity based on the level of intensity (walking = 3.0, moderate = 4.0, and vigorous = 8.0), to give a final output for PA and ST in MET–min/week.

6.3.5 Objectively measured PA and ST

ActiGraph GT3X accelerometers (ActiGraph, Pensacola, FL, USA) were used to objectively measure PA and ST. Data obtained from the GT3X model have been shown to be both valid and reliable across all age groups [19]. Participants were asked to wear the accelerometer on their right hip during waking hours for seven consecutive days, only removing it during time spent swimming, showering, or sleeping.

6.3.6 Semi-Structured Interviews

A purposive sub-sample of 31 participants was invited to take part in one-to-one, semi-structured interviews, which were conducted during the second visit after the participants returned their accelerometers. Participants were purposively selected to ensure maximum variation across the key demographic variables, including age, BMI, and IMD rank. An open-ended interview guide was used to facilitate the discussions and included questions relating to their understanding of what the terms PA and ST mean, the importance of PA for health and diabetes prevention, perceived barriers and facilitators to being more active, and any sociocultural factors influencing their levels of PA and ST. Pilot testing was initially carried out on three South Asian men to evaluate and revise the interview schedule prior to commencing the study; amendments were made to the schedule throughout the data collection period using an iterative process. All interviews were conducted in English, and were audio recorded and transcribed verbatim.

6.4 Data Reduction and Analysis

6.4.1 Quantitative data analysis

Accelerometery data were downloaded and analysed using Actilife 6 software (v6.8.2, Actigraph, LLC, Pensacola, FL, USA). An epoch of 60 s was chosen for analysis [18]; a minimum of 600 min wear time was used as the cut-off point for valid data, with a minimum of four days of valid data required to be included in analyses [19,20]. Non-wear periods were defined as greater than 60 consecutive minutes with zero activity counts. The Freedson et al. [21] cut-off points were used to determine the time spent in various levels of PA (0–99 counts/min = sedentary, 100–1951 counts/min = light intensity activity, 1952–5724 counts/min = moderate intensity activity, 5725–9498 counts/min = vigorous intensity activity, and >9499 = very vigorous intensity activity). These cut-off points have previously been used in South Asian populations and therefore, were deemed appropriate for this study and allowed for comparability with the published data [22,23].

As the IPAQ-long form provides an output in MET–min/week, accelerometer data were also converted to MET–min/week (4 × min of moderate intensity activity + 8 × min vigorous intensity activity) for the purpose of comparing accelerometer-derived to IPAQ-derived MVPA. As data were not normally distributed, a two-step approach was used to normalise the data before statistical analyses were conducted [24], with an initial step of transforming the variables into percentile ranks, followed by a second step of operating an inverse normal transformation to the results from the first step. Descriptive analyses (mean, standard deviation, range, percentage) were conducted for all variables. Independent *t*-tests were performed to compare demographic variables between the full sample and the purposive sub-sample that participated in the interviews. Pearson's correlations were used to examine the relationships between accelerometer-derived MVPA and ST, and IPAQ-derived MVPA and ST. Bland-Altman plots were used to explore the differences between accelerometer- and IPAQ-derived MVPA and ST, with dependent *t*-tests used to examine if differences between self-reported and objective measures significantly differed from zero. The effects of the predictor variables of MVPA and ST were explored using multiple linear regression using the enter method. All statistical analyses were conducted using IBM SPSS statistical analysis software package (Version 22.0; IBM, Armonk, NY, USA).

6.4.2 Qualitative data analysis

Direct content analysis was used to analyse qualitative interviews. This particular approach is suitable for qualitative data analysis when there is pre-existing research on the phenomenon being investigated [25]. In this instance, there is published research on the motivations and facilitators of PA in overweight and obese adults, in addition to their being existing data on perspectives of the use of PA for health promotion in South Asian men [26,27]. The existing research not only contributed to choosing the method of analysis but also steered the process for constructing the interview guide. During the course of developing the interview guide, key themes and concepts emerged, which were then used to build the main coding categories for analysis. All transcripts were coded using the predetermined categories, while a second independent researcher coded a selection of transcripts to ensure agreement in coding. Data that did not fit within the initial coding scheme were assigned as a new code. Once a final coding frame was established, data were re-examined and coded based on the final coding categories.

6.5 Results

6.5.1 Quantitative Results

Fifty-four of the 63 participants (85.71%) recruited into the study met the minimum of four days of valid accelerometery data and were included in the analysis, with 31 participants agreeing to take part in a semi-structured interview. Demographic, anthropometric, blood pressure, and HGS data are reported in Table 6.1, with no differences found in these variables between the 63 participants who were recruited, the 54 participants with valid data, and the 31 participants who participated in the interview. As reported in Table 6.2, participants represented a range of different ethnic and religious backgrounds, with the majority being Indian (71.4%) and Hindu (50.8%).

Table 6.1. Anthropometric characteristics, resting blood pressure, handgrip strength, and index of multiple deprivation data for 63 South Asian men participating in the study.

	Full Study Sample (A) (N = 63)	Sample with valid data included in analyses (B) (n=54)	Sub-sample participating in qualitative interview (C) (n=31)	p Values differences between A and B	p Values differences between A and C	p Values differences between B and C
Age (yrs)	44.83 ± 9.90	44.97 ± 9.79	43.93 ± 10.38	0.449	0.728	0.569
BMI (kg/m^2)	28.06 ± 4.15	27.45 ± 3.14	27.84 ± 3.67	0.816	0.618	0.619
Weight (kg)	81.97 ± 12.99	80.12 ± 10.69	80.82 ± 11.88	0.910	0.354	0.674
Height (cm)	170.84 ± 6.11	170.71 ± 6.10	170.31 ± 6.56	0.715	0.605	0.960
Waist Circumference (cm)	99.73 ± 10.44	98.16 ± 8.59	99.20 ± 9.37	0.242	0.758	0.810
Systolic Blood Pressure (mmHg)	128.22 ± 15.19	128.20 ± 15.90	128.37 ± 16.07	0.687	0.581	0.777
Diastolic Blood Pressure (mmHg)	84.78 ± 9.38	84.71 ± 9.76	84.41 ± 10.42	0.502	0.524	0.786
HGS (kg)	29.86 ± 6.58	29.74 ± 6.88	30.41 ± 7.27	0.890	0.504	0.766
IMD rank	16661.45 ± 9470.80	16907.34 ± 9642.28	19818.48 ± 8281.19	0.102	0.147	0.298

Abbreviations:
BMI = Body Mass Index
HGS = Handgrip Strength
IMD = Index of Multiple Deprivation

Table 6.2. Demographic characteristics of the 54 South Asian men with valid accelerometery data.

Characteristic	Number (%)
Country of birth n (%)	
UK	9 (16.7)
India	39 (72.2)
Pakistan	1 (1.9)
Bangladesh	5 (9.3)
Ethnicity n (%)	
Indian	48 (88.9)
Pakistani	1 (1.9)
Bangladeshi	5 (9.3)
Faith n (%)	
Hindu	26 (48.1)
Sikh	17 (31.5)
Muslim	7 (13.0)
Hare Krishna	2 (3.7)
Buddhist	2 (3.7)
Education n (%)	
University/Higher Education	44 (81.5)
College	6 (11.1)
Secondary School	3 (5.6)
Primary School	1 (1.9)
Self-reported English literacy n (%)	
Excellent	31 (57.4)
Good	16 (29.6)
Fair	6 (11.1)
Poor	1 (1.9)
Self-reported health n (%)	

Excellent	8 (14.8)
Good	31 (57.4)
Fair	14 (25.9)
Poor	1 (1.9)
Taking prescribed medication n (%)	
Yes	23 (42.6)
No	31 (57.4)
Taking blood pressure medication n (%)	
Yes	14 (25.9)
No	40 (74.1)

As reported in Table 6.3, accelerometery-derived data indicated that participants engaged in 298.94 ± 186.60 min/wk of MVPA, with 33 participants (61.1%) recording at least 150 min of MVPA/wk. However, only 13 (24.1%) met the recommendation of 150 min or more of MVPA in 10 or more minute bouts. Accelerometer-derived ST indicated that participants spent 551.40 ± 94.97 min/wk being sedentary, with a mean of 65.27% ± 8.64 of time spent being sedentary.

Table 6.3. Summary of accelerometery measured physical activity in 54 South Asian men with valid accelerometery data

Variables	Mean ± SD
Moderate Intensity PA (min/wk)	284.62 ±183.94
Vigorous Intensity PA (min/wk)	14.2170 ± 26.05
Very Vigorous Intensity PA (min/wk)	0.10 ± 0.45
Total MVPA (min/wk)	298.94 ± 186.60
Sedentary Time (min/wk)	3859.81 ± 664.80
% Time Spent Sedentary	65.27 ± 8.64
Participants meeting current PA recommendation of 150 min of MVPA in 10 or more minute bouts n (%)	13 (24.1)

Abbreviations:

SD = Standard Deviation

PA = Physical Activity

MVPA = Moderate-to-Vigorous Physical Activity

One-way ANOVA analysis reported no significant differences in accelerometer-derived MVPA between the demographic variables of levels of education, ethnicity, or country of birth (p = 0.171, p = 0.761, and p = 0.666, respectively), or ST and the same variables (p = 0.184, p = 0.536, and p = 0.359, respectively).

As shown in Table 6.4, IPAQ-derived MVPA was significantly lower than accelerometer-derived MVPA. In contrast, IPAQ-derived ST was significantly higher than accelerometer-derived ST. Pearson's correlation indicated a moderate significant positive relationship between IPAQ-derived MVPA and accelerometer-derived MVPA ($r = 0.414$, $p = 0.002$), and a moderate positive correlation between IPAQ-derived ST and accelerometer-derived ST ($r = 0.446$, $p = 0.001$). Furthermore, tests comparing Total MVPA, IPAQ MVPA, Total Sedentary, and IPAQ sedentary time between the 54 participants included in analysis and the 31 participants in the purposive sub-sample (herewith referred to as the sub-sample) included in qualitative analyses showed no significant differences between the variables.

Table 6.4. Comparison of IPAQ and accelerometery-derived moderate-to-vigorous intensity physical activity and sedentary time for the 54 participants with valid data, and the 31 participants who participated in qualitative interviews. Data are mean ± standard deviation.

Variables	All (n=54)	Sub-sample (n=31)	p-value from T-test comparison between all participants and the sub-sample	p-value from T-test comparison between Accelerometer and IPAQ
IPAQ MVPA (MET min/wk)	675.65 ± 531.96	764.48 ± 549.90	p=0.211	p<0.001
IPAQ ST (min/d)	577.80 ± 860.66	723.59 ± 1155.01	p=0.205	p<0.001
Accelerometery MVPA (MET min/wk)	1253.02 ±771.23	1409.28 ± 909.91	p=0.195	
Accelerometery ST (min/d)	551.40 ± 94.97	566.74 ± 95.42	p=0.314	

Abbreviations:

IPAQ = International Physical Activity Questionnaire

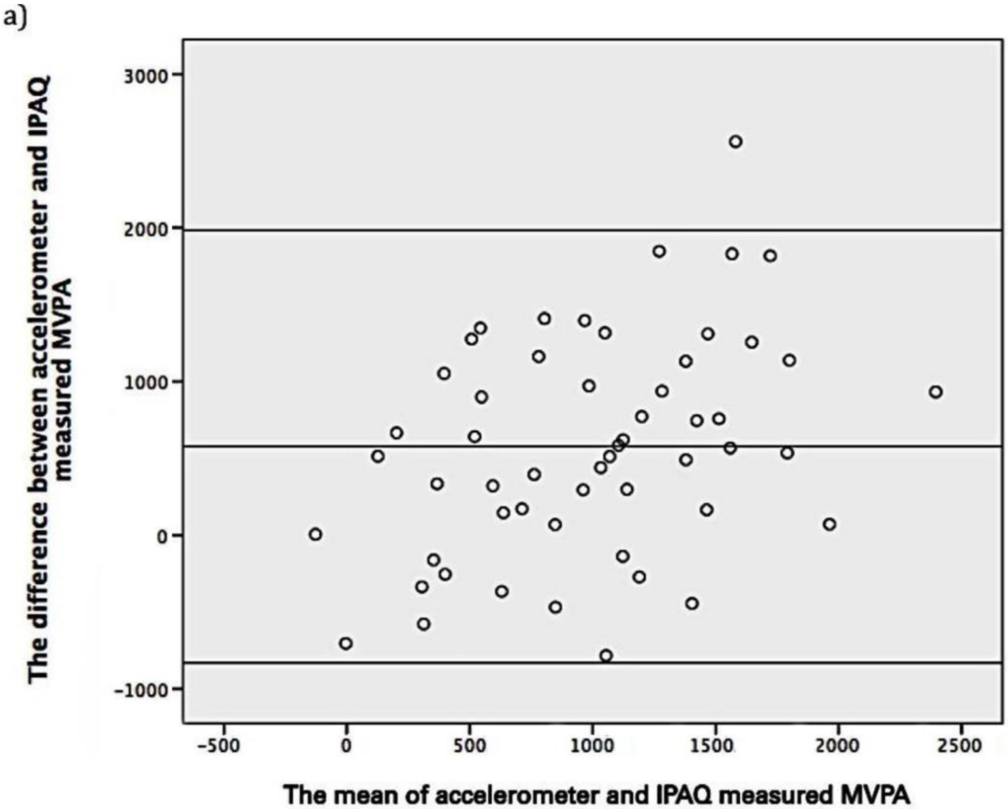
ST = Sedentary Time

MVPA = Moderate-to-Vigorous Physical Activity

MET = Metabolic Equivalent of Task

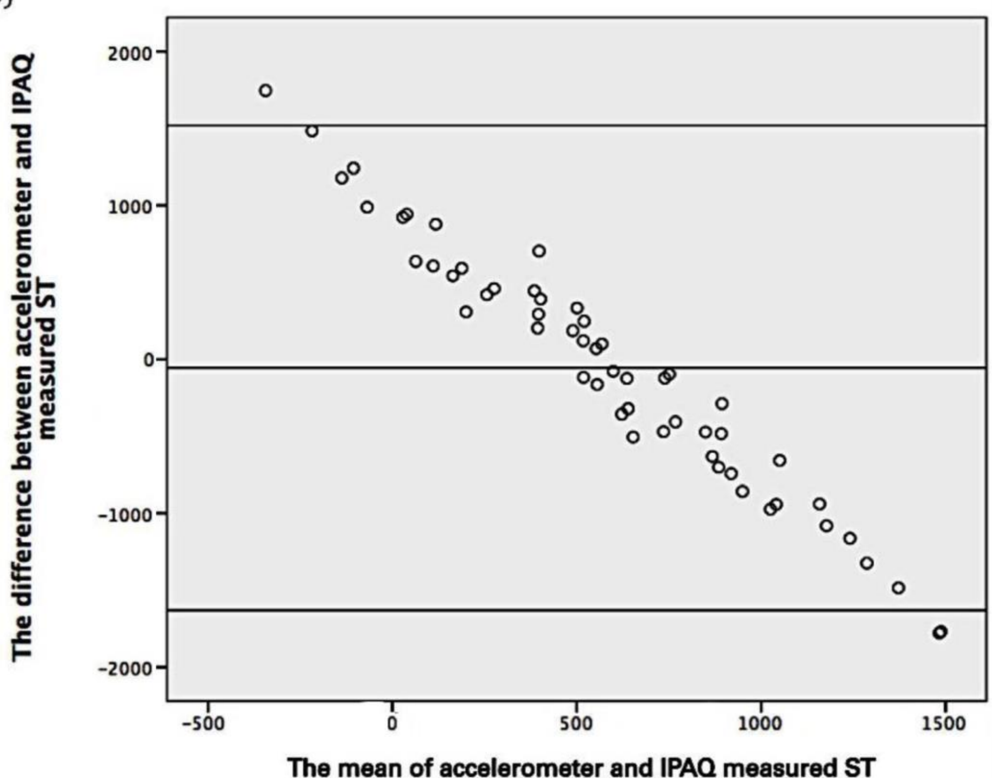
Bland-Altman plots showing the difference between IPAQ and accelerometer-derived MVPA and ST are shown in Figure 6.1. The mean difference between IPAQ-derived and accelerometer-derived MVPA was 578.16 MET-min/wk (P< 0.001) (values are normalised using the 2-step approach) and the 95% limits of agreement were relatively broad (-828.72 to 1985.05). For ST and the mean difference was -56.15 min/d (P = 0.610) (values are normalised using the 2-step-approach) and the 95 % limits of agreement was also relatively broad (-1631.21 to 1518.90).

a)



The difference between accelerometer and IPAQ measured MVPA
3000
2000
1000
0
-1000
-500
0
500
1000
1500
2000
2500
The mean of accelerometer and IPAQ measured MVPA

b)



The difference between accelerometer and IPAQ measured ST
2000
1000
0
-1000
-2000
-500
0
500
1000
1500
The mean of accelerometer and IPAQ measured ST

Figure 6.1. Bland-Altman plots for IPAQ and accelerometry -derived MVPA and ST

a) The difference between accelerometer and IPAQ measured MVPA (y-axis) plotted against the mean of accelerometer and IPAQ measured MVPA (x-axis) with 95% limits of agreement. Overall mean difference was 578.16 MET min/wk and the limits of agreement were -828.72 to 1985.05.

b) The difference between accelerometer and IPAQ measured ST (y-axis) plotted against the mean of accelerometer and IPAQ measured ST (x-axis) with 95% limits of agreement. Overall mean difference was -56.15 MET min/d and the limits of agreement were -1631.21 to 1518.90.

Data shown are normalised using the 2-step approach.

Multiple linear regression models using socio-demographic variables as predictors for accelerometer-derived MVPA resulted in no significant models. However, for accelerometer-derived ST, the IMD rank explained 4.6% of the variance in ST ($F (1, 48) = 4.190$, $p = 0.046$), suggesting that participants living in the least deprived areas have higher levels of ST than those living is more deprived areas.

6.5.2 Qualitative Results:

Figure 6.2 illustrates the final coding matrix of the key factors reported to affect PA and ST as in qualitative interviews.

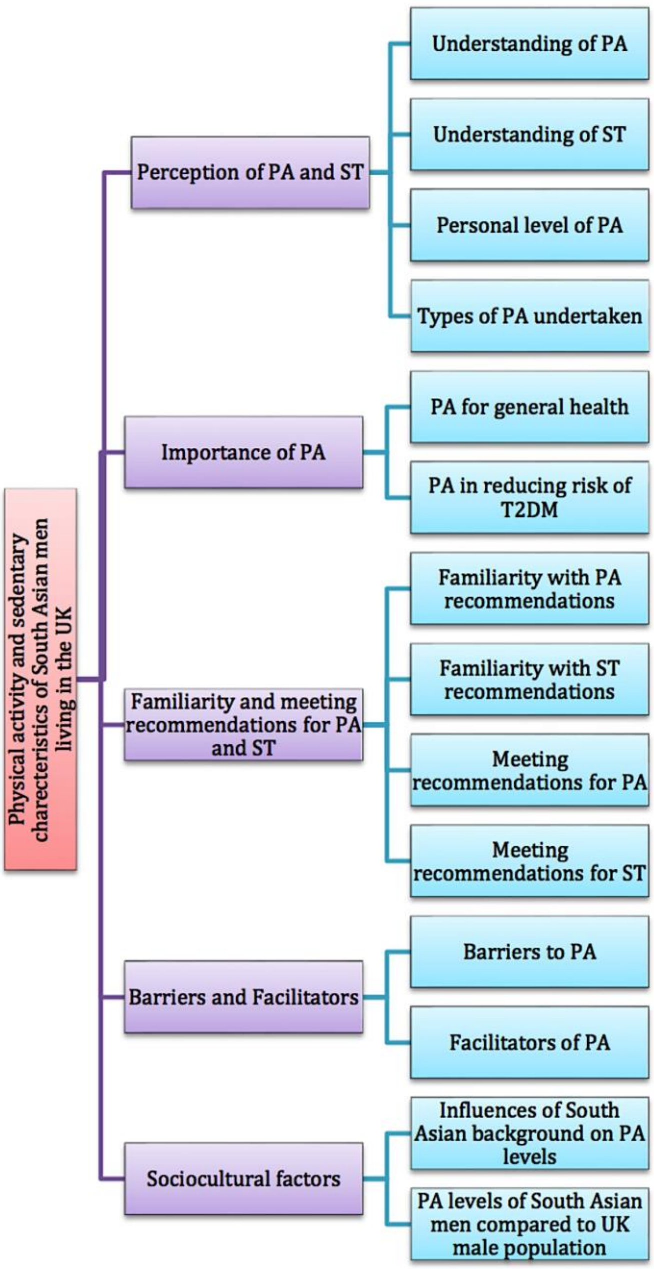


Figure 6.2. Diagram showing the final coding matrix identifying the key factors identified as influencing physical activity and sedentary time in the 31 participants who participated in semi-structured qualitative interviews.

The following sections describe the findings within each code, supported by representative quotes.

6.5.2.1 Understanding of PA

Participants conceptualised PA in two different ways, with half of the men considering PA to be any form of movement:

'You just keeping moving. I would say walking, cycling, any household chores, any games or extracurricular activities. I guess even walking, standing up and sitting down is also considered physical activity'

(47y, Indian, Hindu, living in the UK for 17y)

Whereas the other half of interviewees considered PA to be more than just general movement, often referring to more intense forms of activity:

'Physical activity for me, I think is more than just walking or sitting down would be to do some extra physical activity like exercise or… something out of your comfort zone'

(30y, Indian, Sikh, living in the UK for 5y)

Furthermore, participants emphasised the concept of sweating as being a sign of engaging in adequate PA, with some participants only considering vigorous activity as a legitimate form of PA:

'Physical activity [is], anything that would make me tired and sweat and make me pant, I would classify that as physical activity'
(51y, Indian, Hindu, living in the UK for 23y)

6.5.2.2 Understanding of ST

Over half of the participants (17/31) were not familiar with the term 'sedentary time.' Those who were aware of this term demonstrated a comprehensive understanding:

'It's just like sitting on a chair reading or watching tele [television] or something like that. Sedentary…that is just stationary. Your body is stationary. Maybe [a] little hand movement may be there, otherwise that is, that also could be considered as sedentary'
(63y, Indian, Hindu, living in the UK for 19y)

Others associated ST with being lazy:

'Sedentary, okay. It's that something like laziness? Or sitting quietly, not doing enough movement, like on the couch, sitting watching the telly?'

(49y, Indian, Hindu, living in the UK for 15y)

In contrast, one participant viewed ST as a necessary part of his day to support needs for rest and relaxation:

'Yeah. It's the time when you relax and let your body rest'

(51y, Indian, Hindu, living in the UK for 23y)

6.5.2.3 Personal level of PA

Over half the men (17/31) described their own level of PA as inactive. Furthermore, nearly all the men stated that they were significantly more active over the weekends compared to during the week:

'Weekdays I would say inactive, weekends I'm a bit active. By the time I go [to work] and come back the day is gone, so I don't have much to do during the five days, but Saturday, Sunday I do. Like do some cycling if the weather is good, go out for cycling or badminton every Saturday, Sunday'

(48y, Indian, Hindu, living in the UK for 10y)

The majority of men (21/31) stated that their work commitments were the main reason for the difference in weekday to weekend activity levels. As one participant explained:

‘When I’m at work then I’ll say I’m not very active that’s just the way that my lifestyle is at work, because most of the time I am behind my desk’

(25y, Indian, Sikh, living in the UK for 25y)

6.5.2.4 Types of PA undertaken

Overall walking was reported as the most common form of PA:

‘ [I] walk, very fast, as fast as I can, right, so that, that’s what I try to do. Me and my wife both, both are very similar thinking; we try to do that’

(42y, Indian, Hindu, living in the UK for 11y)

Other activities mentioned included running, swimming, cycling, badminton and football. Badminton in particular was revealed to be one of the more favoured activities to play over the weekends, as it was mentioned by 35.5% of those interviewed:

‘And over the weekend I do make a point to go for badminton for like and hour or an hour and a half, or sometimes two hours. So for example, this Sunday I played for two hours’

(37y, Indian, Hindu, living in the UK for 5y)

Only 3 participants mentioned going to the gym on a regular basis, although many mentioned their desire to join one. Furthermore only two of the participants mentioned including resistance training as part of their routines:

'Normally I go three to four times a week to the gym. So I do probably two days of strength training, not very heavy, just, you know, a moderate level of weights, and maybe 15, 20 miles of running'

(34y, Indian, Hindu, living in the UK for 18y)

6.5.2.5 PA for general health

All of the men considered PA to be important for general health, in particular in relation to promoting weight loss, with some also referring to the perceived benefits for cardiovascular health:

'Well, because it... physical activity helps me to bring down my fat. That's what I'm trying to do actively and then it helps in pumping the heart, which in turn helps in the blood circulation which in turn helps reducing the fat deposits and cholesterol and everything'

(45y, Indian, Hindu, living in the UK for 11y)

The benefits of PA in promoting mental health was also highlighted by some:

'I think [it's] very important. Not even [just for] your physical health but your mental health leaves a lot of stress, but with regards to physical health, yes'

(27y, Indian, Sikh, living in the UK for 27y)

Another theme which emerged was the perceived increased importance of PA with age:

'Because as you go along with your age, you get old, you've got more chances to get any kind of disease. So you need to be having more physical activities, to keep fit yourself, so you can stay away from this type of disease…'
(49y, Indian, Sikh, living in the UK for 30y)

6.5.2.6 PA in reducing risk of T2DM

Apart from three participants who were unsure, the remainder of those interviewed were confident that PA helped reduce the risk of T2DM, with most attributing the benefits to the role of PA in helping to reduce body weight:

'Yes, definitely. Well, first of all it would help me lose my weight, and that I think should have an impact on everything on my health overall and including diabetes'
(47y, Indian, Hindu, living in the UK for 17y)

Others made reference to how they thought PA would affect blood glucose levels:

'Because you are basically, burning all the calories, so you're not, accumulating any, cholesterol or fat in the body, so by doing more [physical activity], you know, burning the energy out, you need less insulin to digest, yeah, otherwise, you need more insulin in the body to get rid of the sugar to compensate'

(47y, Indian, Hindu, living in the UK for 15y)

6.5.2.7 Familiarity with recommendations

Only 5 of the 31 (16.1%) participants were familiar with the PA recommendations of achieving at least 150 minutes of MVPA or 75 min of vigorous activity per week in bouts of 10 min or more. None of the participants were familiar with current ST recommendations of minimising ST.

6.5.2.8 Meeting recommendations

After describing the PA and ST recommendations to the participants, 13 (42.0%) thought they were meeting the recommendation for PA, with only 6 (19.4%) believing they were meeting the recommendation for ST.

6.5.2.9 Barriers to PA

A lack of time was the main theme identified as a barrier to being more active. This was subdivided into a lack of time due to work or family commitments:

'Barriers to me, yeah, it's my work. I have to be in my office and have to be available because I work with, ah, overseas customers, so they expect me to be there, and then I just can't, you know, make time to get out'

(51y, Indian, Hindu, living in the UK for 23y)

'Yeah, just now is the timings you know, dropping the kids you know, at various locations cause my daughter started school now, recently in September and my son's going nursery so my wife's got to drop my daughter and I have to drop my son. So that's taking too much time and by the time I finish there's no time to do exercise'

(30y, Indian, Sikh, living in the UK for 5y)

Some participants also considered the weather to be a barrier, stating that the poor weather in the UK made it more difficult for them to live more active lives:

'For me, the main problem in the UK is the weather, it doesn't allow me to do some [physical activity]... I like to do... go for jogging. If the weather is good, I like to go for... I can go for 10 km at a stretch in the span of one hour, but in winters it's very hard, you need to cover up a lot, and, ah, so that's not motivating me at all'

(40y, Indian, Hindu, living in the UK for 10y)

'Also because of the climate I can't walk as often as I would like to here'

(41y, Indian, Hindu, living in the UK for 10y)

6.5.2.10 Facilitators of PA

Group exercise was the main theme that emerged as a facilitator to being more active, with 11 participants citing the motivating influence of exercising with others:

'Also in a group level, I find that very, very helpful. Obviously when there's other people around, that helps, and it has a kind of a knock-on positive effect as well'
(58y, Indian, Hindu, living in the UK for 54y)

'But I believe that if there are group exercises or something …absolutely, yeah. I think that I can do that'
(46y, Indian, Hindu, living in the UK for 16y)

However 5 men considered personal responsibility to be the most important factor in being more active:

'But I think it is very, very personal driven. As an individual, I know what good it is, and I know what I should be doing' (37y, Indian, Hindu, living in the UK for 5y)

6.5.2.11 Influence of South Asian background

Twenty-four out of the 31 participants (77.4%) believed that their South Asian background has an influence on their PA levels. A prioritisation of academia rather than sports during childhood was the focal point of discussion. As one man explained:

'Because it is not embedded from the childhood that physical activity is, kind of, a must. We are being programmed and attuned to be academic, more academic, and then doing either valid

business or in the career path or kind of thing, so it's more about academic, not much emphasis about physical activity. You know, when I grew up, sports was seen as a waste of time - I can't earn money [engaging in sports]. So it's all about keeping yourself, you know, ahead, for survival'

(47y, Indian, Hindu, living in the UK for 15y)

Nonetheless many believed that circumstances have changed since they were growing up, often drawing comparisons with their own children:

'But of course, it's more of the socio-economic structure at that time, we're talking about the '70s and '80s. So then it was completely different [In India]. But whereas now, when I see the [UK] population in comparison, I think people are equally aware, of the importance [of physical activity]…whereas I take my kid for a particular thing or for different lessons, he goes for cricket, for badminton, swimming, football, so I encourage him to go for many more activities'

(47y, Indian, Hindu, living in the UK for 16y)

The family-orientated nature of South Asian communities was another theme identified as influencing PA levels, with participants reporting that they believed that South Asians men are more dependent on their families compared to other men in the UK:

'Mostly family responsibilities, like, here, people here [in the UK] are very independent, whereas in South Asia they're more family oriented. Like, they live with their parents, so they live with

their families, so they will have more get-togethers, gatherings, so... and they tend to, go in the cars every time so they don't tend to walk a lot, I mean, not do any kind of physical activities'
(40y, Indian, Hindu, living in the UK for 2y)

6.5.2.12 PA levels of South Asian men compared to UK men

The majority (29/31) considered South Asian men living in the UK to be less physically active than the general UK male population, with only two participants believing the contrary. Two participants felt that PA levels were not necessarily different due to ethnicity, but more dependent upon the individual's work environment, as the following quote illustrates:

'They're [Asian men] different, again, it all comes down to their, sort of professional lifestyle a lot of Asian men are you know, if in finance or business you're sitting down a lot, but then a lot of them are in construction or property that do work very vigorously you know, physical work and, no nothing like that, it comes out all down to your routine and your job'
(30y, Indian, Sikh, living in the UK for 5y)

6.6 Discussion:

Using a mixed-methods design, this study quantitatively and qualitatively examined the PA and ST of overweight and obese South Asian men living in the UK. This study provides an important and unique contribution to the literature, and to our knowledge it is the first study to examine the comparability of accelerometer-derived PA and ST to the IPAQ-long form in this population, in addition to being the first to objectively measure ST and to conduct qualitative interviews exploring factors affecting the PA and ST levels in this population.

The mean MVPA and ST for our sample were 298.94 min/week and 551.40 min/day, respectively. Celis-Morales et al. [22], reported lower MVPA levels in South Asian men living in the UK (181.3 min/week), as did Yates et al. in their mixed sample of UK South Asians (126 min/week) [28]. Comparisons with data from the Health Survey for England (HSE) [29] show that mean MVPA in our sample was higher than the 217 min/week reported for the general male adult population, with the mean ST for our sample being considerably higher (551.4 min/day vs. 309 min/day) (Health and Social Care Information Centre 2015) [30]. Furthermore, mean PA and ST levels in our sample were more comparable to data from a sample of South Asian women living in the UK (242.6 min/week of MVPA and 530.2 min/day of ST) [23].

Although there was a moderate significant positive correlation between IPAQ and accelerometer-derived MVPA and ST, the IPAQ significantly underestimated MVPA and overestimated ST. Furthermore as demonstrated by the Bland–Altman plots, the 95% limits of agreement were relatively broad, indicating that the two methods were not likely to be measuring MVPA and ST similarly, therefore the IPAQ-long form may not be suitable for use in this population. Yates et al. measured MVPA in South Asian men and women from a similar age range to our sample, reporting a similar positive correlation between accelerometer and IPAQ-derived MVPA. However, in their sample, self-reported MVPA levels were significantly higher than objectively measured MVPA, as assessed using the IPAQ-short form [28]. Due to having fewer input options for the specific activity domains, the short-form can potentially overestimate PA levels [31]. Results from multiple linear regression analyses suggest that men from least deprived areas had higher levels of ST. This may be in part because people from less deprived areas are more likely to have office-based jobs and hence would spend more time being sedentary [29,32].

The qualitative data in the present study suggest that all of the men who participated in interviews were aware of the importance of PA for general health, and had a good understanding of the role of PA in reducing the risk of T2DM. Only 16.1% of the men interviewed were familiar with the UK guidelines for PA; this value is higher than the 6% of the general male population in the UK who are familiar with current PA guidelines [30].

A lack of time due to work and family commitments was reported as the main barriers to being more active. This is a commonly reported barrier to PA in adults and is not unique to South Asian adults [33]. One important cultural aspect identified in this study is a relatively high level of family commitments, with an emphasis on the expectation that South Asian men prioritise time away from work to spend it with their families as opposed to engaging in leisure time PA. This finding has also been identified in previously published studies of South Asian men [34–36]. Participants also identified the weather as a barrier to being more active, with poor weather in the UK thought to limit their outdoor activity, which is consistent with existing research on South Asian adults living in colder climates [37], in addition to being a common barrier reported by adults across various ethnic minority groups [38,39].

In the present study, participating in exercise with others was reported to be the primary facilitator to being more active. This theme is supported by previous research in South Asian adults [26,27,36]; these studies reported preferences for South Asian adults to socialise while taking part in PA. It is important to note that engaging in exercise with others is a common facilitator for PA in many populations, and is not exclusive to South Asians [33,40].

A unique culture-related finding from our data was the concept that the men felt that their upbringing within a South Asian family placed a greater focus on education over exercise, ultimately influencing their PA levels as adults. Many participants referred to the importance of education in South Asian families and countries as a means to achieve financial stability. In particular, those who grew up in a lower socioeconomic environment in India commented that education was considered the main route to improving quality of life. Hence the cultural lack of focus on PA experienced as children may have impacted the formation of habits and long-term PA behaviours. Some also made cross-cultural comparisons to the higher importance placed on PA in the UK overall, compared to less importance being placed on PA in South Asian countries. This finding is consistent with published research emphasising the development of early childhood habits in relation to being physically active, which in turn will affect PA behaviours in adulthood [41–43]. Some participants in this study suggested that this cultural attitude to PA has begun to change within South Asians who are born and raised in the UK. Their views are supported by research indicating that second- generation South Asians may have a more favourable attitude towards PA compared to first- generation South Asians living in the UK [44]. Participants also revealed how they have provided support for their children to engage in more PA, using their own childhood as a reference point when describing the difference in the amount of extracurricular PA they encourage their own children to take part in, compared to when the participants themselves were children.

Recent evidence suggests that new physical activity recommendations specific to South Asians may be needed to account for this population's increased risk of developing T2DM and other metabolic diseases. Iliodromiti and colleagues [45] investigated the level of MVPA that South Asian adults required to match the same cardio-metabolic risk profile observed in white Europeans of similar age and BMI undertaking the recommended 150 min of MVPA/week. The results of this study indicated that South Asian adults need to be undertaking at least 232 min/week of MVPA to achieve the same cardio-metabolic benefits that white European adults achieve by engaging in 150 min/week. In the present study, the mean min/week of MVPA of South Asian men exceeded the 232 min/week threshold suggested by Iliodromiti et al [45], with 33 participants (61.1%) exceeding this threshold. Although the findings of Iliodromiti et al. need to be replicated in a larger sample, they draw attention to the potential need for physical activity guidelines that are tailored for groups at increased risk for metabolic diseases such as T2DM and cardiovascular disease.

This study was not without limitations. The sample size was relatively small, and therefore is likely not representative of South Asian men living in the UK, which limits the generalizability of our results. In addition, 81.5% of our participants were university educated, which may also limit the generalizability of our findings to the wider population. However it is important to note that recent research suggest that Indians of Sikh and Hindu faith are more likely to achieve higher levels of education than other South Asian groups, and as such our findings provide insights into this sub- group within the economically and culturally diverse classification of 'South Asians' in the UK [46].

One strength of our study was objectively measuring PA and ST to allow for comparisons with self-report data. Another strength of this study was the recruitment of individuals who have traditionally been defined as 'hard-to-reach', along with the inclusion of South Asian men across a range of ages, faith groups, and countries of origin. Upon initiating this research, we believed that an additional strength of this study was incorporating the use of the long-form version of the IPAQ instead of the short-form version used in previous research [23,28]. Based on previous research, it was expected that the long-form version would provide a more accurate estimate of MVPA than the short-form, but our findings suggest this was not the case. As such, it appears that the utility of both the short- and long-form versions of the IPAQ may be limited in this population.

As our results indicate that exercising with others is a main facilitator to engaging in PA in this sample, future intervention programmes encouraging group exercise should be promoted as a strategy for increasing PA levels. Based on the participants' responses, team sports such as group badminton, football, and cricket appeared to be favourable to the men, and as such could be implemented in community and faith centres to increase participation and acceptance. Furthermore, given the high levels of objectively measured ST and the lack of awareness about recommendations to reduce ST, future intervention should focus on awareness campaigns in community centres and places of worship to promote the importance of ST reduction.

6.7 Conclusion:

Our data indicate that this sample of South Asian men are more physically active than has been previously reported in studies using objectively measured methods. Nonetheless, most are not meeting the recommendation of 150 min of MVPA per week in 10 or more minute bouts.

However, more data are needed to determine whether this holds true in a larger, more representative sample of South Asian men, and to compare their MVPA levels to those of the general UK population. The results suggest that the IPAQ-long form may not accurately measure MVPA and ST in South Asian men living in the UK. This study revealed additional information about the unique socio-cultural factors which affect PA engagement in overweight and obese South Asian men. It is crucial that healthcare professionals and researchers understand these behaviours in order to tailor advice and future intervention to address the needs of this population.

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CHAPTER 7

GENERAL DISCUSSION

7.1 Overview

This thesis used a mixed-methods approach to comprehensively examine the dietary, physical activity (PA) and sedentary time (ST) of overweight and obese South Asian men living in the UK. With implementing a broad range of methods (e.g. systematic review, self-report questionnaires, accelerometers and semi-structured interviews), significant new evidence has been produced, adding to our understanding of these behaviours, as well as the strength of methods used to measure PA and ST in this at-risk population. In particular, through the utilisation of a systematic review, all available studies published in the English language were examined and synthesised to determine if there was an optimal diet for glycaemic control in overweight and obese adults with T2DM, beyond the effects of weight loss. Furthermore, the literature review highlighted the importance of diet and PA as the two key lifestyle-related behaviours influencing T2DM, as well as demonstrating that published data examining these behaviours in UK South Asian men was limited. This provided a justification for this thesis, as there is a clear need to fill these gaps in knowledge by assessing diet, measuring PA and ST levels, and using semi-structured interviews to exploring the factors influencing dietary and PA behaviours in this population.

This final chapter highlights the main findings from the three studies (Chapter 4-6) in this thesis. Furthermore, a discussion of the implications of the results for practice and future research is also provided.

7.2 Summary of research findings: Study 1

As revealed in the literature review (Chapter 2) there were many different dietary interventions used to treat patients with T2DM. After critically examining the interventions it became apparent that many of the trials were reporting significant benefits of one dietary arm over another in improving glycaemic control, despite the fact that there were significant differences in weight loss between the dietary arms. Given the integral role of weight loss in treating patients with T2DM (Franz et al. 1994), this raised the question of whether the benefits reported in these studies were due to the specific macronutrient profiles of the diets themselves, or due to fact that the group who manage to reduce total caloric intake, and subsequently lost the most weight ended up exhibiting better improvements in glycaemic control. Therefore a systematic review was conducted to address this issue. Study 1 (Chapter 4) was a quantitative systematic review that assessed the effects of various dietary interventions on glycaemic control in overweight and obese adults with T2DM while controlling for weight loss between dietary arms.

The aim of the study was to answer the following research questions (as previously stated in Chapter 1):

RQ 1. Is there an ideal diet for optimising glycaemic control in overweight/obese adults with T2DM?

The majority of studies did not demonstrate a benefit of one particular dietary intervention over another, with only 4 showing a significant difference in glycaemic control despite a non-significant difference in weight loss (Fabricatore et al. 2011, Esposito et al. 2009, Elhayany et al. 2010, Barnard et al. 2009). These diets included the low-carbohydrate Mediterranean (LCM) diet, low-fat vegan diet and the low-GI diet. Although Elhayany et al. demonstrated the benefit of a LCM diet over an American Diabetes Association ADA diet; there was no control over the effects of glucose-lowering medications on HbA1c, with authors not reporting either participant's baseline medication use or any subsequent changes during the duration of the intervention. Therefore it is unclear whether the benefits observed were due to the dietary intervention itself or the effects of glucose-lowering medication. The three interventions which showed promise where Barnard et al. who showed a possible advantage of a low-fat vegan diet compared with the ADA diet, Fabricatore et al, who demonstrated the benefit of a low- GL diet over a low-fat diet, and Esposito et al. who demonstrated the benefit of using an LCM diet over a low-fat diet.

Based on the limited data there is insufficient evidence to conclude that a specific diet is superior to another for improving glycaemic control in overweight and obese adults with T2DM. Most of the studies which met our inclusion criteria revealed no difference between diets when there were no significant differences between weight loss between groups, indicating that weight loss itself is the crucial factor influencing glycaemic control. The low-GI, LCM and low-fat vegan diets did appear promising as they seemed to be more effective than their respective comparators. To be able to establish whether there is a superior diet for improving glycaemic control, changes need to be made to the research design of dietary RCTs.

This study makes a significant contribution to the understanding of the role of diets of varying macronutrient profiles in reducing HbA1c levels in overweight/obese adults with T2DM, highlighting the importance of weight loss over specific macronutrient profiles, as well as reporting on the limitations of current dietary interventions.

To our knowledge, this was the first study to attempt to control for the effect of weight loss between dietary arms in RCTs. Based on findings there was insufficient evidence to state that a particular diet is superior for glycaemic control. Therefore current guidelines set by the ADA to reduce total energy intake should be the primary strategy.

7.3 Summary of research findings: Study 2

Study 2 (Chapter 5) of the thesis was designed based on the key findings of the literature review chapter (Chapter 2) and the systematic review (Chapter 4). The limited data on dietary intake and factors influencing eating behaviours in UK South Asian men as revealed in the literature review, along with the importance of weight loss and dietary fibre as demonstrated by the systematic review, were used as the foundation for choosing to the UKDDQ as the method for assessing diet in overweight and obese South Asian men living in the UK.

The aims of this cross-sectional mixed methods study were to 1) quantify food intake and dietary behaviours using the UK Diabetes and Diet Questionnaire (UKDDQ), and 2) using semi-structured interviews to explore the factors influencing eating behaviours.

The aims of this study was to answer the following research questions (as previously stated in Chapter 1):

RQ 2. What are the current dietary intake patterns of overweight and obese UK South Asian men who are at risk of developing T2DM?

RQ 3. What are the barriers and facilitators to making positive dietary changes in overweight and obese UK South Asian men who are at risk of developing T2DM?

In contrast to previous qualitative data on South Asian men (Lucas et al. 2013), most of the participants exhibited a good understanding of the key risk factors contributing to the development of T2DM, with diet, physical activity, body weight, sedentary time and genetics all being identified as risk factors. This may be explained by the fact that the majority were University educated (81%). Furthermore another unique finding was the method by which the men were accessing information regarding diet and health. In contrast to previous data suggesting the 'word of mouth' was the main source of information, most of the participants highlighted online sources as the primary outlet for diet and health related information, suggesting a change in the way South Asian men are accessing information. Cultural commitments, in particular, the high frequency and duration of festivals were reported my most as the key barrier preventing South Asian men from making positive dietary changes, often representing periods of over-consumption of unhealthy foods.

A central finding was the lack of control men believed they had over their food consumption. The vast majority of married men (96.6%) reported that their wives were responsible for preparing food at home, with most (78.8%) also stating that their wives were predominantly responsible for the grocery shopping. The distinct lack of control the men had became evident when some even requested that their wives be present when completing the UKDDQ, as they believed their wives would be better informed to answer some of the questions.

This study provided much-needed information to address the gap in knowledge about current dietary intake patterns in overweight and obese UK South Asian men, by using the newly validated UKDDQ. The current data has demonstrated that areas in need of dietary improvement in the men were similar to those observed in the general UK population. This study also revealed the unique socio-cultural challenges South Asian men face when attempting to improve dietary intake.

7.4 Summary of research findings: Study 3

Study 3 (Chapter 6) of the thesis was designed based on the key findings of the literature review chapter (Chapter 2) and the systematic review (Chapter 4). Chapter 2 revealed the importance of PA and ST in reducing the risk of T2DM, with Chapter 4 highlighting the importance of weight loss. The shortage of data objectively measuring PA and ST, as well as the nonexistence of data assessing the comparability of the IPAQ-long form with accelerometer-derived PA and ST in overweight and obsess South Asian men living in the UK was also shown by the literature review. Therefore PA and ST characteristics and behaviours were examined in this population.

The aims of this study were to 1) quantify PA and ST using both self-report and objectively measured methods, and 2) to use semi-structured interviews to explore the factors influencing PA and sedentary behaviours in overweight and obese UK South Asian men.

This study addressed the following research questions (as previously stated in Chapter 1):

RQ 4. What are the levels of objectively measured PA and ST among overweight and obese UK South Asian men who are at risk of developing T2DM?

RQ 5. Are self-report methods comparable to objective methods for measuring PA and ST in these men?

RQ 6. What are the barriers and facilitators to engaging in PA that are reported by overweight and obese UK South Asian men?

The mean MVPA was 298.94 ± 186.60 min/wk and the mean ST was 3859.81 ± min/wk, although 61.1% of participants recorded at least 150 min/wk of MVPA, only 24.1% managed to achieve this in 10 or more minute bouts. Therefore although mean MVPA was relatively high, only 24.1% were meeting the UK recommendations for PA. Two previous studies which objectively measured MVPA in UK South Asian men reported lower MVPA than that found in the current sample (Celis-Morales et al. 2013, Yates et al. 2015). Additionally, the mean MVPA of the current sample was also higher than that reported by the HSE for the general male adult population (HSCIC 2015). Therefore the data appears to suggest that this sample of overweight and obese South Asian men living in the UK are more active than previously reported, comparable to the general male adult population.

There were moderate significant positive relationships between IPAQ and accelerometer-derived MVPA and IPAQ and accelerometer-derived ST. However, the IPAQ significantly underestimated MVPA and overestimated ST. Furthermore, Bland-Altman plots demonstrated that the 95% limits of agreement were relatively wide, indicating that the two methods were not likely to be measuring MVPA and ST similarly. Further validation in larger more representative samples of UK South Asians is needed to determine if the IPAQ-long form is a valid tool for measuring MVPA and ST in this population.

A lack of time due to work, family commitments and poor weather, were identified as the main barriers to being physically active. These barriers were similar to those reported in previous studies on UK South Asians (Lawton et al. 2006, Abbott and Riga 2007, Darr et al. 2008, Oliffe et al. 2009), however they are not unique to South Asians (Withall et al. 2011, Shiu-Thornton et al. 2004, Wieland et al. 2013).

Exercising with others was identified as the primary facilitator to being more active. Most of the men believed that exercising in groups was a motivating influence. This is commonly supported by existing data on South Asian adults (Cross-Bardell et al. 2015, Jepson et al. 2012, Oliffe et al. 2009) although again not exclusive to South Asians (Withall et al. 2011, Allender et al. 2006)

The majority (77.4%) believed that their South Asian backgrounds have an influence on their PA levels. A unique finding was that the men felt that their upbringing within a South Asian family placed greater priority on education over exercise, ultimately influencing their PA behaviours as adults. This finding is supported by published research demonstrating the importance of the development of early childhood PA habits on determining PA levels during adulthood (Telma et al. 2014, Hallal et al. 2006, Gordon-Larsene et al. 2004).

This study provided a much-needed examination of PA and ST characteristics of overweight and obese South Asian men living in the UK. These data add to the limited published data objectively measuring PA, as well as being the first to measure ST objectively and to test the validity of the IPAQ-long form in this population.

7.5 Limitations and directions for future research:

This thesis provides a thorough examination of the dietary and physical activity characteristics of overweight and obese South Asian men living in the UK. All three studies have increased knowledge in this area and have helped to fill the respective gaps in the literature. However these studies are not without limitations, and acknowledging these limitations can assist future research in this area.

Study 1 (Chapter 4) examined the effects of various dietary interventions on glycaemic control in overweight and obese adults with T2DM when controlling for weight loss between dietary interventions. As the randomised controlled trials lacked a standard control diet for comparison, a meta-analysis could not be conducted. Therefore a narrative approach was used to synthesise all the resulting evidence. The interpretation of the results was limited by the lack of details provided in many of the trials. In particular, the lack of clarity on medication use made it unclear whether reductions in HbA1c were due to the dietary interventions or the effects of the medication. Therefore caution must be taken when interpreting the results of this study. This suggests that it is essential for future trials to report the use of glucose-lowering medication at baseline and any adjustments in doses made throughout the duration of the trial. Given the importance of weight loss in glycaemic control, it is recommended that future dietary trials both compare diets that are isocaloric and attempt to ensure similar expenditure between dietary arms, to try to control for the effects of weight loss. Once there are sufficient trials adhering to these criteria, meta-analyses can be conducted to determine whether there is, in fact, an ideal diet for optimising glycaemic control in overweight/obese adults with T2DM.

Study 2 (Chapter 5) quantified food intake and dietary behaviours using the UKDDQ and used semi-structured interviews to explore the factors influencing eating behaviours in overweight and obese South Asian men in the UK. A limitation of this study was the highly educated (81% having a university degree), relatively small sample size, which may limit the generalisability of the data to the larger male UK South Asian population. Future studies should recruit larger sample sizes and attempt to include men from a wider range of educational backgrounds to better represent the wider population. Once diet is assessed using the UKDDQ in larger samples, comparisons can be made between South Asian men and other populations. Furthermore, this study only recruited men who were fluent in English. Therefore, future studies using interpreters would provide comparison data to explore the effect of language contextualisation on assessing diet and PA using self-report methods.

Study 3 (Chapter 6) quantified PA and ST using both self-report and objectively measured methods, as well as using semi-structured interviews to explore the factors influencing PA and sedentary behaviours in overweight and obese South Asian men living in the UK. Since the sample in this study was the same sample participating in study 2 (Chapter 5), the same sampling limitations apply. Therefore as with study 2, the findings of this study may also not be generalisable to the wider male UK South Asian population. The non-random nature of this study may have meant that men who were more interested in PA would have chosen to take part. Hence they may have been more aware of the benefits of PA, as well as possibly being more physically active than the broader population. Future research in larger samples is need to determine PA and ST levels of South Asian men with other populations as well as to assess the validity of the IPAQ-long form for use with South Asian men.

Given that recent data has suggested that South Asian men should undertake a minimum of 232 min/wk of MVPA to achieve the same cardiometabolic benefits that white Europeans adults attain by engaging in 150 min/wk (Iliodromiti et al. 2016), it is of interest for future research to explore the potential for specific PA guidelines for South Asians to account for their increased risk of metabolic diseases such as T2DM.

As accelerometers cannot measure the static component of exercise, they are not able to accurately measure resistance-training activity (Westertep 1999). As such, this thesis was unable to assess resistance training in UK South Asian men. Current UK guidelines recommend adults undertake muscle strengthening exercises at least twice a week (UK DoH 2011). However data reporting on levels of resistance training amongst UK South Asian men is non-existent. Similar to aerobic training, resistance training can help improve insulin sensitivity and help to reduce abdominal fat (Bacchi et al. 2012). Furthermore, a prospective study of 508, 332 men over an 18-year period, demonstrated a dose-response relationship between time spent weight training and lower risk of T2DM (Grøntved et al. 2012). Therefore given the benefits of resistance training for T2DM prevention, future research needs to assess this behaviour in South Asian men, while exploring to see whether, like aerobic activity (Iliodromiti et al. 2016), South Asian men respond differently to resistance training compared with white populations.

7.6 Implications for policy and practice

Lifestyle interventions can be effective in reducing the incidence of T2DM (Diabetes Prevention Program Research Group 2002, Li et al. 2008, Tuomilehto et al. 2001, Costa et al. 2012). Furthermore, interventions have been culturally adapted for ethnic minority populations, with particular success in Hispanic (Ockene et al. 2012, Ruggiero et al. 2011) and African-American (Sattin et al. 2016, Spencer et al. 2011) populations in the United States (US). However, a recent systematic review concluded that diabetes interventions targeting South Asians living in Europe have led to little improvements in HbA1c levels, highlighting the need for novel strategies for these populations (Bhurji et al. 2016).

Although successful lifestyle interventions in UK South Asians is limited, Bhopal et al. achieved modest weight loss in overweight/obese South Asian adults by using a culturally adapted family-based lifestyle intervention (Bhopal et al. 2014). This supports the findings from this thesis, with men identifying family support as an important facilitator to making lifestyle changes, therefore interventions using a family-based model could be advantageous for UK South Asian men. Another key finding from the dietary data was the perceived lack of control that married men felt they have over their food preparation. A pair of individuals in a dyadic relationship can have an influence on each other's behaviours (Kelley et al. 1983), and spousal influence has been shown to be beneficial for diabetes management (Anderson et al. 2016, August et al. 2013), increasing adherence to PA (Ayotte et al. 2013, Beverly and Wray 2010), and improving effectiveness of weight loss interventions (Cornelius et al. 2016, Golan et al. 2010). In particular, wives have been shown to have a positive effect on their husband's dietary adherence (Seidel et al. 2012, Allen et al. 2013). Therefore based on the existing data and the findings of this thesis, it is recommended that intervention programmes focus on family-based interventions, mainly looking at involving the men's wives when implementing lifestyle changes.

Given the central role that places of worship have in ethnic minority communities, they are an ideal location for implementing community-based interventions. As demonstrated by a systematic review conducted by DeHaven et al. 2004, faith-based programmes can be effective in improving health outcomes (DeHaven et al. 2004). Additionally, faith-based interventions have been particularly successful in African-American populations in the US, where church-based programmes have been shown to improve diet and increase PA levels (Duru et al. 2010, Sattin et al. 2016, Tussing-Humphrey et al. 2013, Yanek et al. 2001).

Although UK-based South Asian faith-based programmes are limited, the ‘Apnee Sehat Project’ based in Warwickshire is a good example of how such programmes can be implemented within South Asian communities (Coe and Boardman 2008). This project worked within the Sikh community using the Gurdwara (Sikh temple) as the basis for the project. This project included employing Sikh dietitians to work in close cooperation with Gurdwara kitchen staff to implement healthier alternatives to traditional foods, as well as making alternatives to the traditional high fat/high sugar sweets eaten during festivals such as Diwali, with few individuals reporting to notice any changes to the taste. Given that the Gurdwaras provides free food 7-days of the week, and are the primary location for religious festivals for the Sikh community, they represent a unique position for effecting widespread influence on the community. If changes like this can be implemented within places of worship around the UK, it would enable South Asian men to have access to healthier alternatives, not only during visits to the centre, but more importantly during festival periods which this thesis found was a primary barrier for many of the men when making positive dietary change. Likewise, in the US a pilot study using a quasi-experimental two-arm design, a programme run by community health workers in collaboration with community stakeholders achieved significant reductions in weight, BMI and waist circumference and increases in PA in Sikh Indians who attended group education sessions at a Gurdwara in New York City (Islam et al. 2014). Furthermore, a recent feasibility study looking at reducing the risk of T2DM in UK South Asians in Leicester, also revealed that group-education within faith centres represented a feasible and acceptable strategy, achieving a high-uptake of participants (Willis et al. 2016). Therefore faith-based organisations should be utilised in the delivery of community-based programmes when possible.

To implement programmes such as the Apnee Sehat Project, collaboration is needed between community groups and primary care providers. The Apnee Sehat Project was achievable because of the collaborative efforts of the National Diabetes Support Team, Diabetes UK and the Gurdwara. Working with local community groups, such organisations can help initiate lifestyle programmes while enabling the communities themselves to take control. This will allow long-term sustainable programmes to be available for the members of the community.

As most men in the present thesis did not achieve the minimum recommendation of 150 min/wk of MVPA/wk in 10 or more min bouts, programmes are needed to promote MVPA. Based on the qualitative findings of the thesis, team sports or group-based exercise programmes might be a useful method for encouraging sustained MVPA. The men reported exercising with others as an important facilitator to being more active. Members of a PA group who identify as a unit will express a greater sense of cohesiveness towards achieving a goal (Forsyth 1998), with group cohesion along with the development of personal relationships playing a significant role in increasing PA levels (Watson et al. 2004). Research has shown that group-based physical activity interventions can be effective for a range of populations including ‘hard to reach’ populations (Harden et al. 2015). Therefore programmes encouraging South Asian men to exercise together should be promoted as a method for increasing their PA levels. Based on the participants’ responses, team sports such as group badminton, football and cricket appeared to be favourable to the men, and as such could be implemented in community and faith centres to increase participation and acceptance. During the recruitment process for studies 2 and 3, it was evident that some faith-centres did have basic exercise facilities, which could be used for such sports.

Again, outside help from organisations working with the centres to initiate such programmes in the communities would be beneficial.

Additionally, walking was mentioned as a regular form of PA for the men, therefore implementing walking groups within the community would also be a relatively cheap and highly accessible alternative for encouraging PA while maintaining the social aspect desired by the men. Meta-analyses have shown that walking groups are effective in increasing PA levels and improving health outcomes (Hanson and Jones 2015, Kassavou et al. 2013). Furthermore, a recent study looking at the implementation of walking groups in communities with the greatest health needs highlighted the role of utilising community-based assets at a grass root level to enhance the effectiveness of walking group schemes (Hanson et al. 2016). This is supported by the success of community health promoter facilitated walking group interventions in a Black and Hispanic community in the US (Schulz et al. 2015). By utilising community centres and faith-based organisations, this 32-week intervention significantly increased PA and reduced fasting blood glucose in participants who took part compared with controls. Therefore by using the current facilities available to the different South Asian communities, such programmes can be implemented to provide affordable and accessible opportunities for UK South Asian men to engage in more PA.

This thesis found that most men believed that their main barrier to reducing ST was the demands of their predominantly office-based jobs. Furthermore, none of the men were familiar with the recommendation to minimise ST. Given that most participants mentioned online technologies as the primary source for accessing health-related information, online campaigns would be an easily accessible and affordable method for raising awareness about the benefits of reducing ST. Additionally given the demands of the office-based working environment, reducing weekday ST is an area, which can also be targeted. Although not unique to South Asians, a recent meta-analysis did demonstrate a -39.6 min/8-hour workday pooled intervention effect of a workplace intervention to reduce ST (Chu et al. 2016). Furthermore, the use of mobile applications to promote the reduction of ST may be a feasible option. Recent data have shown that an 8-week intervention using mobile phone applications can significantly reduce accelerometer measured ST in overweight and obese adults (King et al. 2016), and therefore may appeal to the men as a useful tool to help reduce their weekday ST.

Based on the findings of the systematic review (Chapter 4) and dietary data (Chapter 5) from this thesis, general practitioners (GPs) and health care professionals should continue to encourage overweight/obese South Asians male patients to reduce body weight to achieve ideal BMI scores (< 23.0 kg/m^2). As currently there is no evidence of a particular diet to promote, nutritional advice for South Asian men should be to focus on reducing caloric consumption and in particular to promote the reduction of sugar-sweetened beverages. Furthermore, as of this year, GPs have been instructed to identify individuals at risk of T2DM and refer them to the National Diabetes Prevention Program (NDPP), where they can access behavioural interventions to reduce their risk (NHS DPP 2016). However, there are no published data to date on the impact of the NDPP on diabetes risk, so it remains to be seen whether it will be effective for South Asian men or whether uptake to the NDPP from ethnic minority groups will be successful. Therefore it is important that GPs are aware of any additional local community-based initiatives for South Asians so that men can be informed of such programmes if the GPs deem them be effective.

7.7 Conclusions

In conclusion, this thesis used a mixed-methods approach to examine the diet, PA and ST of overweight and obese South Asian men, and to explore the factors influencing these variables. Findings from this thesis indicate that future research needs to assess dietary intake in larger samples to enable comprehensive comparisons to be made with the general population and other ethnic groups. Furthermore, objective methods should be the preferred option for measuring PA and ST, while more research is needed to determine if the IPAQ-long form is valid for use in this population. The findings from this thesis can be used to inform policy makers, general practitioners (GPs), Diabetes UK, and other diabetes educators about developing culturally tailored campaigns, programmes and interventions aimed at improving dietary intake, increasing PA and reducing ST in overweight and obese South Asian men living in the UK, to contribute to reducing T2DM rates in this high-risk population. By working in collaboration, such organisations can help empower local South Asian communities to run culturally-adapted programmes tailored to address the needs of overweight and obese South Asian men living in the UK.

7.7 References

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Appendix 1. Table of search terms for the 4 databases used

	Medline	Embase	CINAHL	Web of Science
1	Diabetes Mellitus, Type 2/	Diabetes Mellitus, Type 2/	(MH “Diabetes Mellitus, Type 2”)	diab* near/3 (“type 2” or mellitus)
2	(diabet* adj3 (“type2” or mellitus))	(diabet* adj3 (“type2” or mellitus))	NIDDM	NIDDM
3	NIDDM	NIDDM	Diabet* n3 (“type 2” or mellitus)	Type 2 diabetes mellitus
4	Haemoglobin A, Glycosylated/	Haemoglobin A, Glycosylated/	(MH “Hemoglobin A, glycosylated”)	Refined by: Diabete mellitus
5	Haemoglobin a/ or haemoglobin a, glycosylated/	Haemoglobin a/ or haemoglobin a, glycosylated/	Glyc* h?emoglobin	Diabetes mellitus
6	Glyc*h?emoglobin	Glyc*h?emoglobin	HbA1c	1 or 2 or 3 or 4 or 5
7	GHb	GHb	GHb	HbA1c
8	Glycoh?emoglobin	Glycoh?emoglobin	(MH “Diet+”)	Glyc*h?emoglobin
9	Diet	Diet	(MH “Diet Therapy+”)	Glycoh?emoglobin
10	Exp Diet/	Exp Diet/	Diet*	GHb
11	Exp diet therapy/ or diet, reducing/	Exp diet therapy/ or diet, reducing/	(calor* or energy*) n2 intak*	Hemoglobin-glycosylated A1c
12	Diet*	Diet*	(protein* or Mediterranean* or carbohydrate* or fat* or vegetarian* or vegan*) n3 (diet* or intake*)	7 or 8 or 9 or 10 or 11
13	((calor* or energ*) adj2intak*)	((calor* or energ*) adj2intak*)	(MH “Dietary Proteins+”)	Diet*
14	((protein* or	((protein* or Mediterranean* or	(MH “Dietary	(Calor* or energy*) near/2

	Mediterranean* or carbohydrat* or fat* or vegetarian* or vegan*) adj3 (diet* or intak*))	carbohydrat* or fat* or vegetarian* or vegan*) adj3 (diet* or intak*))	Carbohydrates+")	intak*
15	Energy intake	Energy intake	(MH "Dietary Fats+")	(protein* or Mediterranean* or carbohydrate* or fat* or vegetarian* or vegan*) near/3 (diet* or intak*)
16	Exp energy intake/	Exp energy intake/	(MH "Glycemic Index") OR (MH "Glycemic Load")	Glyc?emic index
17	Exp Dietary Proteins/	Exp Dietary Proteins/	Glyc?emic index	Glyc?emic load
18	Exp Dietary Fats/	Exp Dietary Fats/	Glyc?emic load	Nutrition*
19	Exp Dietary Carbohydrates/	Exp Dietary Carbohydrates/	Calories	13 or 14 or 15 or 16 or 17 or 18
20	Glycemic Index/	Glycemic Index/	Caloric	(19 and 12 and 6) and language: (English)
21	Glyc?emic index	Glyc?emic index	1 or 2 or 3	Randomized controlled trials
22	Glyc?emic load	Glyc?emic load	4 or 5 or 6 or 7	20 and 21
23	Calories	Calories	8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20	Weight*
24	Caloric	Caloric	21 and 22 and 23	
25	1 or 2 or 3	1 or 2 or 3	(MH "Body Weight Changes+")	22 and 23
26	4 or 5 or 6 or 7 or 8	4 or 5 or 6 or 7 or 8	Weight *	
27	9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21	9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or	25 or 26	

	or 22 or 23 or 24 or 25 or 26 or 27	26 or 27	
28	25 and 26 and 27	25 and 26 and 27	24 and 27
29	Limit 28 to (English language and humans and “all dult (19 plus years)” and randomized controlled trial)	Limit 28 to (English language and humans and “all dult (19 plus years)” and randomized controlled trial)	
30	Body weight / or body weight changes/ or weight gain/ or weight loss/ or overweight/ or thinness/	Body weight / or body weight changes/ or weight gain/ or weight loss/ or overweight/ or thinness/	
31	(weigh* adj3 (los* or gain* or decrease* or increase* or change* or difference*))	(weigh* adj3 (los* or gain* or decrease* or increase* or change* or difference*))	
32	30 or 31	30 or 31	
33	29 and 32	29 and 32	

Appendix 2. Table of quality of included studies assessed using the JBI critical appraisal tool

First author, year of publication (reference)	Was the assignment to treatment groups truly random?	Were participants blinded to treatment allocation?	Was allocation to treatment groups concealed from the allocator?	Were the outcomes of people who withdrew described and included in the analysis?	Were those assessing outcomes blind to the treatment allocation?	Were the control and treatment groups comparable at entry?	Were groups treated identically other than for the named interventions?	Were outcomes measured in the same way for all groups?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?	Overall appraisal
Guldbrand 2012	YES	NO	NO	NO	UNCLEAR	YES	YES	YES	YES	YES	INCLUDE
Brehm 2009	YES	NO	UNCLEAR	NO	UNCLEAR	YES	YES	YES	YES	YES	INCLUDE
Fabricatore 2011	YES	NO	NO	YES	UNCLEAR	YES	YES	YES	YES	YES	INCLUDE
Elhayany 2009	YES	NO	YES	YES	UNCLEAR	YES	YES	YES	YES	YES	INCLUDE
Barnard 2009	YES	NO	NO	YES	YES	YES	YES	YES	YES	YES	INCLUDE
Esposito 2009	YES	NO	NO	YES	YES	YES	YES	YES	YES	YES	INCLUDE
Pedersen 2014	YES	NO	YES	NO	YES	YES	YES	YES	YES	YES	INCLUDE
Iqbal 2010	YES	NO	UNCLEAR	YES	UNCLEAR	YES	YES	YES	YES	YES	INCLUDE
Ma 2008	YES	NO	UNCLEAR	NO	UNCLEAR	YES	YES	YES	YES	YES	INCLUDE

Milne 1994	YES	NO	UNCLEAR	NO	UNCLEAR	YES	YES	YES	YES	YES	INCLUDE
Larsen 2011	YES	NO	YES	YES	YES	YES	YES	YES	YES	YES	INCLUDE

Appendix 3. UKDDQ

UK Diabetes and Diet Questionnaire (UKDDQ) Participant ID: **Date:**

Think about your diet over the last MONTH. **Please tick or circle the answer that best applies to you.**		Never or very rarely	Once a week or less often	2- 4 times a week	5 - 6 times a week	1 – 2 times a day	3 or more times a day	**Score**
1.	How often did you eat a portion of vegetables? • Include fresh, tinned and frozen vegetables. A portion is 80g (see the back sheet for what this looks like).							
2.	How often did you eat a portion of fruit? • Include fresh, frozen, tinned and dried fruit. Do not count fruit juices. A portion is 80g (see the back sheet for what this looks like).							
3.	How often did you eat a cake, a sweet pastry like a Danish pastry, a donut or a sweet biscuit?							
4.	How often did you eat some sweets or a bar of chocolate?							
5.	How often did you drink sugary drinks? • Include non-diet fizzy drinks, squashes, mixers, energy drinks, fruit juices or coffee, tea or other hot drinks with sugar or flavoured syrups.							
6.	How often did you use full-fat spread (butter or a full fat margarine) on your bread, potatoes or vegetables?							

		Never or very rarely	Less than once a week	Once a week	2 – 5 times a week	Nearly every day or daily	Twice or more per day	**Score**
7.	How often did you eat full-fat cheese? Include cheese in sandwiches, on biscuits, in sauces and when used as a topping. • Full fat cheeses include hard cheeses like cheddar, blue cheeses and soft cheeses like brie or cream cheese or full-fat goat cheeses.							
8.	How often did you eat processed meat? Include processed meat in sandwiches, ready meals and if eaten as a snack. • Processed meat includes foods like bacon, ham, spam, sausages, salami or chorizo.							
9.	How often did you eat savoury foods like crisps, corn chips, corn puffs, salted nuts or Bombay mix?							
10.	How often did you eat a savoury pastry? • Think about food like pies, pasties, samosas, sausage rolls or vol-au-vents.							
11.	How often did you eat 'fast foods' from a take-away or in a restaurant? • Think about foods like burgers, fish and chips, fried chicken, donor kebabs, pizza, fried rice or curries with cream or ghee.							
12.	How often did you eat pudding or dessert, apart from fruit, with your meals?							
13.	How often did you drink alcohol?							
14.	How often did you eat oily fish? • Think about fresh or tinned salmon, trout, sardine, mackerel, pilchards, herring or red mullet, or fresh tuna.	Never	Less than once a week	Once a week	Twice or more per week			

Page 1 Version 1.91 25.09.2015: Interviewer scored

UK Diabetes and Diet Questionnaire (UKDDQ) Participant ID: **Date:**

Think about your diet over the last MONTH. **Please tick or circle the answer that best applies to you.**	Never or very rarely	Less than once a week	Once a week	2 – 4 times a week	5 – 6 times a week	Every day	**Score**
15. How often did you have 3 or more regular meals in a day? • Include light meals like a sandwich or a soup and roll. • Don't include snack times when you ate only a biscuit or cake or a piece of fruit or vegetable sticks or a packet of crisps or piece of cheese.							
16. How often did you eat breakfast (more than just a drink or one or two sweet biscuits) within about 2 hours of waking?							
17. How often did you 'snack' or 'pick' on high-fat or high-sugar foods between meals? • Think about food like biscuits, chocolate, cakes, crisps, nuts and cheese.							

18. • How often did you eat a portion of bread? • Include bread in sandwiches and wraps. A portion of bread is 1 slice of bread, a bread roll, half a baguette, a bagel, a tortilla wrap, a small naan, a chapatti or a paratha.	Never or very rarely	Once a week or less than once a week	2- 6 times a week	1 – 2 times a day	3 – 4 times a day	More than 4 times a day	
19. If you ate bread how often did you choose higher fibre breads? • Breads that are high in fibre include wholemeal, granary, multi-grain or rye breads. • If you follow a gluten free diet include high fibre gluten free breads.	All of the time	Most of the time	About half the time	Less than half the time	Never	I did not eat bread	**Score**
20. How often did you eat a bowl of breakfast cereal, porridge or muesli?	Never or very rarely	Less than once a week	Once a week	2 – 5 times a week	Nearly every day or daily	Twice or more per day	
21. If you ate breakfast cereal how often did you choose higher fibre cereals? • Cereals that are high in fibre include porridge, muesli, Weetabix, Shredded Wheat, multi-grain cereals and wheat or oat bran cereals.	All of the time	Most of the time	About half the time	Less than half the time	Never	I did not eat cereals	**Score**

22. What type of milk did you usually use, if any?	Full fat (cow, goat or sheep)	Semi-skimmed (cow, goat or sheep)	Skimmed (cow, goat or sheep)	Sometimes full fat, sometimes skimmed or semi skimmed	Soya, oat, rice or other non-dairy milk.	None	**Score**

23. Are you concerned about your weight?	I am not concerned about my weight	I am a little concerned about my weight	I am moderately concerned about my weight	I am very concerned about my weight

24. How important is it to you to change your diet? — Not at all important 0 3 5 7 10 Extremely important

25. How confident are you that you could change your diet? — Not at all confident 0 3 5 7 10 Extremely confident

Scoring

How many As or Bs?	How many Cs?	How many Ds?	How many Es?	How many Fs?
____ / 20	____ / 20	____ / 20	____ / 20	____ / 20

What do the scores mean?

As and **B**s = **Healthy** dietary choices
Cs and **D**s = **Less healthy** dietary choices
Es and **F**s = **Unhealthy** dietary choices

Lower scores mean better dietary habits. Look back at the questions where you scored more than D. You can use these as a guide to see where you can make healthy changes.

Use your answers to questions 23, 24 and 25 to think about and discuss how much you want to make changes to your diet and whether you think changes are possible.

I plan to think about these changes...

1.

2.

3.

Notes:

Question 2 (Fruit)	Be aware that more than 3 portions of fruit per day may contribute to raised blood glucose levels. Portions of fruit should be evenly spread out during the day.
Question 13 (Alcohol)	Scoring for alcohol does not take into account binge drinking. It is likely that drinking more than once a day exceeds guidelines.
Question 14 (Oily fish)	The omega-3 fatty acids are essential and must be consumed in the diet. For vegetarians, or people who dislike oily fish, good alternate sources are rapeseed oil (commonly vegetable oil), flaxseed oil, walnut oil, ground flaxseeds, chia seeds and walnuts, edamame (cooked soy beans) and tofu. If appropriate consider foods fortified with omega-3s, such as omega-3 eggs.
Question 22 (Milk)	If the response is soya, oat, rice or other non dairy milk or no milk you may want to discuss other sources of calcium such as calcium fortified foods, tofu set with calcium salts, tinned fish with bones, broccoli and spring greens.

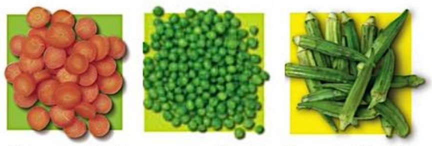
Portion size guides

Question 1: How often did you eat a portion of vegetables?

A portion of fresh, raw, tinned and frozen vegetables is 80g

These are some examples of what counts as a portion:

2 florets of broccoli or cauliflower or 4 tablespoons green, leafy vegetables



3 heaped tablespoons of cooked vegetables like carrots, peas, okra or courgettes

A dessert or cereal bowl of salad

7 cherry tomatoes

Question 2: How often did you eat a portion of fruit?

A portion of fresh, tinned, frozen or cooked fruit is 80g

These are some examples of what counts as a portion:

1 medium fruit like a banana, apple, orange, pear, peach or nectarine

2 small fruit like plums or satsumas

10 chunks of tinned pineapple

A handful of grapes or berries

A 5cm slice of a large fruit like a melon or pineapple

A tablespoon of dried fruit

UK Diabetes and Diet Questionnaire: Scoring page 1

	Never or very rarely	Once a week or less than once a week	2- 4 times a week	5 - 6 times a week	1 – 2 times a day	3 or more times a day
Question 1 (Vegetables)	F	E	D	C	B	A
Question 2 (Fruit)	F	E	D	C	B	A
Question 3 (Cakes, biscuits)	A	B	C	D	E	F
Question 4 (Sweets and chocolate)	A	B	C	D	E	F
Question 5 (Sugary drinks)	A	B	C	D	E	F
Question 6 (Full fat spreads)	A	B	C	D	E	F
	Never or very rarely	**Less than once a week**	**Once a week**	**2 – 5 times a week**	**Nearly every day or daily**	**Twice or more per day**
Question 7 (Cheese)	A	B	C	D	E	F
Question 8 (Processed meat)	A	B	C	D	E	F
Question 9 (Crisps and salty snacks)	A	B	C	D	E	F
Question 10 (Pies, pasties and savoury pastries)	A	B	C	D	E	F
Question 11 (Fast food)	A	B	C	D	E	F
Question 12 (Pudding)	A	B	C	D	E	F
Question 13 (Alcohol)	A	A	B	C	E	F
Question 14 (Oily fish)	**Never**	**Less than once a week**	**Once a week**	**Twice or more per week**		
Question 14 (Oily fish)	F	D	B	A		

 Version 1.91 25.09.2015: Interviewer scored

UK Diabetes and Diet Questionnaire: Scoring page 2

	Never or very rarely	**Less than once a week**	**Once a week**	**2 – 4 times a week**	**5 – 6 times a week**	**Every day**
Question 15 (Regular meals)	F	E	D	C	B	A
Question 16 (Breakfast)	F	E	D	C	B	A
Question 17 (Snacking)	A	B	C	D	E	F
Question 18 (Breads, quantity)	No score. Can be used with question 19, 20 and 21 to discuss wholegrain / fibre intakes.					
Question 19 (High fibre breads)	**All of the time**	**Most of the time**	**About half the time**	**Less than half the time**	**Never**	**I did not eat bread**
	A	B	C	E	F	A
Question 20 (Breakfast cereal)	No score. Can be used with question 19, 20 and 21 to discuss wholegrain / fibre intakes.					
Question 21 (High fibre break-fast cereal)	**All of the time**	**Most of the time**	**About half the time**	**Less than half the time**	**Never**	**I did not eat cereals**
	A	B	C	E	F	A
Question 22 (Type of milk)	**Full fat**	**Semi-skimmed**	**Skimmed**	**Mixture**	**Soya, oat, rice or other non-dairy milk**	**None**
	F	C	A	D	A	A

Appendix 4. IPAQ-long form

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (October 2002)

LONG LAST 7 DAYS SELF-ADMINISTERED FORMAT

FOR USE WITH YOUNG AND MIDDLE-AGED ADULTS (15-69 years)

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health–related physical activity.

Background on IPAQ

The development of an international measure for physical activity commenced in Geneva in 1998 and was followed by extensive reliability and validity testing undertaken across 12 countries (14 sites) during 2000. The final results suggest that these measures have acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

Using IPAQ

Use of the IPAQ instruments for monitoring and research purposes is encouraged. It is recommended that no changes be made to the order or wording of the questions as this will affect the psychometric properties of the instruments.

Translation from English and Cultural Adaptation

Translation from English is encouraged to facilitate worldwide use of IPAQ. Information on the availability of IPAQ in different languages can be obtained at www.ipaq.ki.se. If a new translation is undertaken we highly recommend using the prescribed back translation methods available on the IPAQ website. If possible please consider making your translated version of IPAQ available to others by contributing it to the IPAQ website. Further details on translation and cultural adaptation can be downloaded from the website.

Further Developments of IPAQ

International collaboration on IPAQ is on-going and an ***International Physical Activity Prevalence Study*** is in progress. For further information see the IPAQ website.

More Information

More detailed information on the IPAQ process and the research methods used in the development of IPAQ instruments is available at www.ipaq.ki.se and Booth, M.L. (2000).
Assessment of Physical Activity: An International Perspective. Research Quarterly for Exercise and Sport, 71 (2): s114-20. Other scientific publications and presentations on the use of IPAQ are summarized on the website.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** and **moderate** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

PART 1: JOB-RELATED PHYSICAL ACTIVITY

The first section is about your work. This includes paid jobs, farming, volunteer work, course work, and any other unpaid work that you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and caring for your family. These are asked in Part 3.

1. Do you currently have a job or do any unpaid work outside your home?

☐ Yes

☐ No ➞ ***Skip to PART 2: TRANSPORTATION***

The next questions are about all the physical activity you did in the **last 7 days** as part of your paid or unpaid work. This does not include traveling to and from work.

2. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, heavy construction, or climbing up stairs **as part of your work**? Think about only those physical activities that you did for at least 10 minutes at a time.

_____ days per week

☐ No vigorous job-related physical activity ➞ ***Skip to question 4***

3. How much time did you usually spend on one of those days doing **vigorous** physical activities as part of your work?

_____ hours per day
_____ minutes per day

4. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads **as part of your work**? Please do not include walking.

_____ days per week

☐ No moderate job-related physical activity ➞ ***Skip to question 6***

5. How much time did you usually spend on one of those days doing **moderate** physical activities as part of your work?

_____ hours per day
_____ minutes per day

6. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **as part of your work**? Please do not count any walking you did to travel to or from work.

_____ days per week

☐ No job-related walking → ***Skip to PART 2: TRANSPORTATION***

7. How much time did you usually spend on one of those days **walking** as part of your work?

_____ hours per day
_____ minutes per day

PART 2: TRANSPORTATION PHYSICAL ACTIVITY

These questions are about how you traveled from place to place, including to places like work, stores, movies, and so on.

8. During the **last 7 days**, on how many days did you **travel in a motor vehicle** like a train, bus, car, or tram?

_____ days per week

☐ No traveling in a motor vehicle → ***Skip to question 10***

9. How much time did you usually spend on one of those days **traveling** in a train, bus, car, tram, or other kind of motor vehicle?

_____ hours per day
_____ minutes per day

Now think only about the **bicycling** and **walking** you might have done to travel to and from work, to do errands, or to go from place to place.

10. During the **last 7 days**, on how many days did you **bicycle** for at least 10 minutes at a time to go **from place to place**?

_____ days per week

☐ No bicycling from place to place → ***Skip to question 12***

11. How much time did you usually spend on one of those days to **bicycle** from place to place?

_____ **hours per day**
_____ **minutes per day**

12. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No walking from place to place → ***Skip to PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY***

13. How much time did you usually spend on one of those days **walking** from place to place?

_____ **hours per day**
_____ **minutes per day**

PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

This section is about some of the physical activities you might have done in the **last 7 days** in and around your home, like housework, gardening, yard work, general maintenance work, and caring for your family.

14. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, chopping wood, shoveling snow, or digging **in the garden or yard**?

_____ **days per week**

☐ No vigorous activity in garden or yard → ***Skip to question 16***

15. How much time did you usually spend on one of those days doing **vigorous** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

16. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, sweeping, washing windows, and raking **in the garden or yard**?

_____ **days per week**

☐ No moderate activity in garden or yard → ***Skip to question 18***

17. How much time did you usually spend on one of those days doing **moderate** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

18. Once again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, washing windows, scrubbing floors and sweeping **inside your home**?

_____ **days per week**

☐ No moderate activity inside home → ***Skip to PART 4: RECREATION, SPORT AND LEISURE-TIME PHYSICAL ACTIVITY***

19. How much time did you usually spend on one of those days doing **moderate** physical activities inside your home?

_____ **hours per day**
_____ **minutes per day**

PART 4: RECREATION, SPORT, AND LEISURE-TIME PHYSICAL ACTIVITY

This section is about all the physical activities that you did in the **last 7 days** solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

20. Not counting any walking you have already mentioned, during the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **in your leisure time**?

_____ **days per week**

☐ No walking in leisure time → ***Skip to question 22***

21. How much time did you usually spend on one of those days **walking** in your leisure time?

_____ **hours per day**
_____ **minutes per day**

22. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like aerobics, running, fast bicycling, or fast swimming **in your leisure time**?

_____ **days per week**

☐ No vigorous activity in leisure time → ***Skip to question 24***

23. How much time did you usually spend on one of those days doing **vigorous** physical activities in your leisure time?

_____ hours per day
_____ minutes per day

24. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis **in your leisure time**?

_____ days per week

☐ No moderate activity in leisure time → ***Skip to PART 5: TIME SPENT SITTING***

25. How much time did you usually spend on one of those days doing **moderate** physical activities in your leisure time?
_____ hours per day
_____ minutes per day

PART 5: TIME SPENT SITTING

The last questions are about the time you spend sitting while at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Do not include any time spent sitting in a motor vehicle that you have already told me about.

26. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekday**?

_____ hours per day
_____ minutes per day

27. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekend day**?

_____ hours per day
_____ minutes per day

This is the end of the questionnaire, thank you for participating

Appendix 5. Visit 1 semi-structured interview guide

Overview:

The purpose of the study is to find out factors that influence how South Asian men at risk of Type 2 Diabetes eat. The information gathered from this study may help health professionals and policy makers to target strategies to promote healthy dietary practices among South Asian men.

Start recording interview

1) **Perception of Type 2 Diabetes** (aim: to explore what the participant understands about Type 2 Diabetes and it's potential causes)

- What does Type 2 Diabetes mean to you?
- What do you think causes Type 2 Diabetes?
- How much do you think an individual can do to prevent Type 2 diabetes?

2) **Importance of dietary intake** (aim: to explore how important the participant views dietary intake and what they understand about the role of diet in preventing and managing Type 2 Diabetes)

- What does 'healthy eating' mean to you?
- Do you think your diet is healthy?
- In your opinion, what would a healthy diet to prevent diabetes look like?
- Where did you learn your information about healthy eating?

(Here the interviewer will administer and score the UKDDQ)

'Do you think the UKDDQ is suitable for use with people from a South Asian background'? (If not, why not)
'Are there any sweet or fatty foods that are commonly eaten by people from a South Asian background that you think should be included on the questionnaire?'

3) **Barriers and facilitators to making dietary changes** (aim: to explore what factor influences the ability of the participant to make dietary changes)

- Based on your questionnaire scores, to what extent are you willing to make changes to your diet? *(Prompt-include specific questions relating to areas of the participants diet that need improvement)*
- What would you need to help you make these dietary changes?
- What factors might make it difficult for you to make these positive changes to your diet?

4) **Sociocultural factors influencing dietary changes** (aim: to understand how being from a South Asian background may influence the participant's ability to make dietary changes)

- Do you think being from a South Asian background influences your eating behaviours? If so how?
- Could you describe the influence of cultural traditions and norms have on your eating practices and food choices?
- Could you describe any challenges related to being a South Asian man that affect your ability to eat a 'healthier diet'?
- How much control do you feel you have over the food you eat, including content, how it is prepared, etc.? *(Prompt- what factors can you control)*

Appendix 6. Visit 2 semi-structured interview guide

Overview:

The purpose of the study is to find out factors that influence how physically active South Asian men at risk of Type 2 Diabetes are. The information gathered from this study may help health professionals and policy makers to target strategies to promote healthy dietary practices among South Asian men.

Start recording interview

1) **Perception of physical activity and sedentary time** (aim: to explore what the participant understands about the concepts of physical activity and sedentary time)

- What does the word or term 'physical activity' mean to you? *(Prompt- provide a definition of the term is the participant is unfamiliar with the term)*
- What does the word or term 'sedentary time' mean to you? *(Prompt- provide a definition of the term is the participant is unfamiliar with the term)*
- Would you consider yourself as an active or inactive person? Why?
- Could you please tell me how physical activity fits in to a typical day for you?

2) **Importance of physical activity** (aim: to explore how important the participant views physical activity and what they understand about the role of physical activity in preventing and managing Type 2 Diabetes)

- How important do you think physical activity is for your health?
- Do you believe physical activity can reduce your risk of developing Type 2 diabetes?

3) **Barriers and facilitators to being more physically active** (aim: to explore what factor influences the ability of the participant to make changes to their activity levels)

- Are you familiar with the current recommendations for physical activity and sedentary time? *(Prompt- define these if participant is not familiar with these)*
- Do you think you are meeting the current physical activity and sedentary time recommendations? Why or Why not?

- If you are not meeting the current recommendations, what factors would help you to be more active?
- Are you aware of any health messages or programmes available to you that refer to physical activity?
- What would it will take to help you be more active? (Prompt – explore personal, family-based, and broader community and policy-based factors)
- What factors make it difficult for you to be more physically active?

4) **Sociocultural factors influencing physical activity and sedentary time** (aim: to understand how being from a South Asian background may influence the participant's ability to be more physically active)

- How do you think being from a South Asian background influences your physical activity levels?
- Could you describe the importance that cultural traditions and norms have on your activity levels and your level of sedentary time?
- Are there any additional challenges of being a South Asian man when trying to be more physically active or reducing your sedentary time?
- Do you think South Asian men are more or less active than the general UK population?

APPENDIX 7. Confirmation of ethics approval

Dear Professor Thompson & Professor Duda

Re: "Dietary behaviours, physical activity and sedentary time of South Asian men"
Application for Ethical Review ERN_15-0518

Thank you for your application for ethical review for the above project, which has now been reviewed by the Science, Technology, Engineering and Mathematics Ethical Review Committee.

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for your project, subject to the Committee's satisfaction with your response to the following conditions:

* The Committee have suggested that it may be helpful to include some background information in the Participant Information Sheet regarding the prevalence of type 2 diabetes in South Asian men, and reasons for such prevalence, so participants are aware of why they are being asked to take part
* Please ensure that participants are informed of where visits will take place, that they can choose to skip any questions they do not wish to answer, and are provided with a specific deadline/timescale for when withdrawal from the study can be up to
* Please ensure that language is consistent within the participant documentation (e.g. using 'activity monitor' or 'accelerometer', and not both)
* Please consider including additional support mechanisms for participants who may be concerned about developing type 2 diabetes/identified as being 'at risk', or would like assistance with a family member/friend who has diabetes, in addition to referring them to their GP (e.g. relevant support organisation details).

I would be grateful if you could confirm by email to [redacted] that these conditions will be met, and also provide the requested information and documentation prior to the commencement of the study.

I would like to remind you that any substantive changes to the nature of the study as described in the Application for Ethical Review, and/or any adverse events occurring during the study should be promptly bought to the Committee's attention by the Principal Investigator and may necessitate further ethical review.

Please also ensure that the relevant requirements within the University's Code of Practice for Research and the information and guidance provided on the University's ethics webpages (available athttps://intranet.birmingham.ac.uk/finance/accounting/Research-Support-Group/Research-Ethics/Links-and-Resources.aspx) are adhered to and referred to in any future applications for ethical review. It is now a requirement on the revised application form (https://intranet.birmingham.ac.uk/finance/accounting/Research-Support-Group/Research-Ethics/Ethical-Review-Forms.aspx) to confirm that this guidance has been consulted and is understood, and that it has been taken into account when completing your application for ethical review.

Thank you,

Gemma Williams
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Web: www.birmingham.ac.uk/researchsupportgroup<http://www.birmingham.ac.uk/researchsupportgroup>