Physical and mental health of university athletes with and without Type 1 Diabetes

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2 THESIS ABSTRACT

Type 1 diabetes (T1D) is an autoimmune disease that is characterised by fluctuations in blood glucose levels causing a patient to experience hypo- and hyperglycaemia. T1D is typically managed through exogenous insulin therapy and tight management regarding dietary intake. A key benefit aiding the management of T1D is physical activity (PA) due to its positive impact on the maintenance of blood glucose levels and its effect on mental health and overall lifestyle. Transitioning into the university lifestyle presents overwhelming factors that affect an athlete's physical and mental health. Due to these factors, prioritising meeting the guidelines for physical activity and adequate nutritional intake may be lacking, contributing towards poorer mental well-being, and sleeping patterns. University athletes have additional accountabilities that they have to meet whilst juggling a range of academic and non-academic responsibilities that allow them to remain within university and 'fit-in' with social aspects. (Chapter 1) A literature review exploring the nature of T1D and how it affects those of an athlete status transitioning to university, considering PA, nutrition, mental well-being, and sleep. (Chapter 2) An experimental study investigating the impact of university lifestyles on the overall health, well-being, and performance of university athletes through the use of questionnaires within a university athlete population (n=98). (Chapter 3) A further experimental study investigating the adipose parameters and metabolic measures of university athletes, assessing whether there are differences between a T1D and non-T1D university athlete population. Exploring whether university lifestyles impact the overall health status of these groups despite the routine changes as a result of attending university.

Key words: Type 1 Diabetes, physical activity, nutrition, mental well-being, sleep, adipose parameters, metabolic measures, university lifestyle

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6 ABBREVIATIONS

BC	Body Composition
BG	Blood Glucose
BLP	Blood Lipid Profile
BMC	Bone Mineral Content
BMI	Body Mass Index
CT	Computed Tomography
DEXA	Dual-energy X-ray Absorptiometry
DSMQ	Diabetes Self-Management Questionnaire
FFQ	Food Frequency Questionnaire
FMHS	Fat Mass Height Squared
HDL	High-Density Lipoproteins
IPAQ	International Physical Activity Questionnaire
LDL	Low-Density Lipoproteins
MPA	Moderate aerobic Physical Activity
MRI	Magnetic Resonance Imaging
NICE	National Institute of Health and Care Excellence
PA	Physical Activity
PAID	Problem Areas in Diabetes
PHQ	Patient Health Questionnaire
SD	Standard Deviation
T1D	Type 1 Diabetes/Diabetics

TC	Total Cholesterol
TRGLY	Triglycerides
VAT	Visceral Adipose Tissue
VPA	Vigorous aerobic Physical Activity
WC	Waist Conference

7 THESIS OVERVIEW

7.1 THESIS JUSTIFICATION

Type 1 diabetes (T1D) is an autoimmune disease that affects many individuals, worldwide. It presents issues for athletes, demanding a balance between regulating blood glucose levels and optimising performance. Athletes with T1D must navigate the complexities of insulin control, dietary intake, and physical activity to prioritise their health and sporting goals.

Not only do T1D athletes experience the physical challenges of maintaining blood glucose levels but also overwhelming effects on their mental health. Constant attention required for insulin administration and carbohydrate monitoring as well as avoiding hypoglycaemia and hyperglycaemia can contribute to increased stress, depression, and anxiety.

The transition period from secondary to university education presents itself as an extremely overwhelming time and university students are typically a ‘forgotten group’ within research. Furthermore, being an athlete at university poses additional challenges associated with juggling academic and non-academic responsibilities. Being a university athlete with T1D demands the balance of training, competitions, and academic duties with the constant need for blood glucose monitoring and insulin regulation.

Research is lacking around the topic of university athletes and the impact that university lifestyle has on physical and mental health, especially when concerning those who suffer with underlying health conditions such as T1D.

7.2 THESIS AIMS

This thesis aims to investigate the physical and mental health of T1D university athletes. To achieve this, two studies were conducted:

Study 1: The impact of university lifestyle on the health, well-being, and performance of university athletes

Specific study aims:

1. Investigate the impact of university lifestyle on a student athlete's health, well-being, and performance.
2. Explore the differences between university athletes with and without T1D in terms of their physical activity levels, mental well-being, nutritional behaviours, and quality of sleep.

Study 2: The comparison of the adipose indices and metabolic health of university athletes with and without Type 1 diabetes

Specific study aims:

1. Assess and compare the adipose indices and metabolic measures of university athletes living with and without T1D.
2. To predict potential behaviours of university athletes through measuring their average amount of exercise.

7.3 THESIS OUTLINE

Chapter 1 introduces the diagnosis of T1D and how university athletes living with the condition are impacted by key components contributing towards optimal performance: sports and exercise, nutrition, sleep, and mental well-being. Chapter 2 is an investigation into how the university lifestyle impacts the health, well-being and performance of university athletes with a focus on those with T1D. Chapter 3 compares the non-diabetic university athlete with those with T1D, to determine potential differences in adipose indices and metabolic health as well assessing physical activity levels to explore the level of knowledge, support and care that is prioritised against academic and non-academic responsibilities. Chapter 4, experimental findings are discussed and critiqued to determine limitations and ideas for potential future research.

1

Physical and Mental Health of Type 1 Diabetic University Athletes

8 TYPE 1 DIABETES: AN INTRODUCTION

8.1 TYPE 1 DIABETES

The International Diabetes Federation estimates that 8.8% of adults have diabetes globally (2). Type 1 diabetes (T1D) affects only 10–15% of people; type 2 diabetes mellitus is the more dominant variant, creating an immense strain on the healthcare system due to its multiple comorbidities (2). However, T1D affects more than 500,000 children worldwide and is the most common type of diabetes in children under 15 years of age, however, a cure is yet to be discovered (2). Globally, the prevalence of T1D is rising, and it is anticipated that almost 90,000 children are diagnosed with the condition every year (2). Research from Kellet et al. (3), states that there are approximately 25,357 young people, suffering with T1D in the UK.

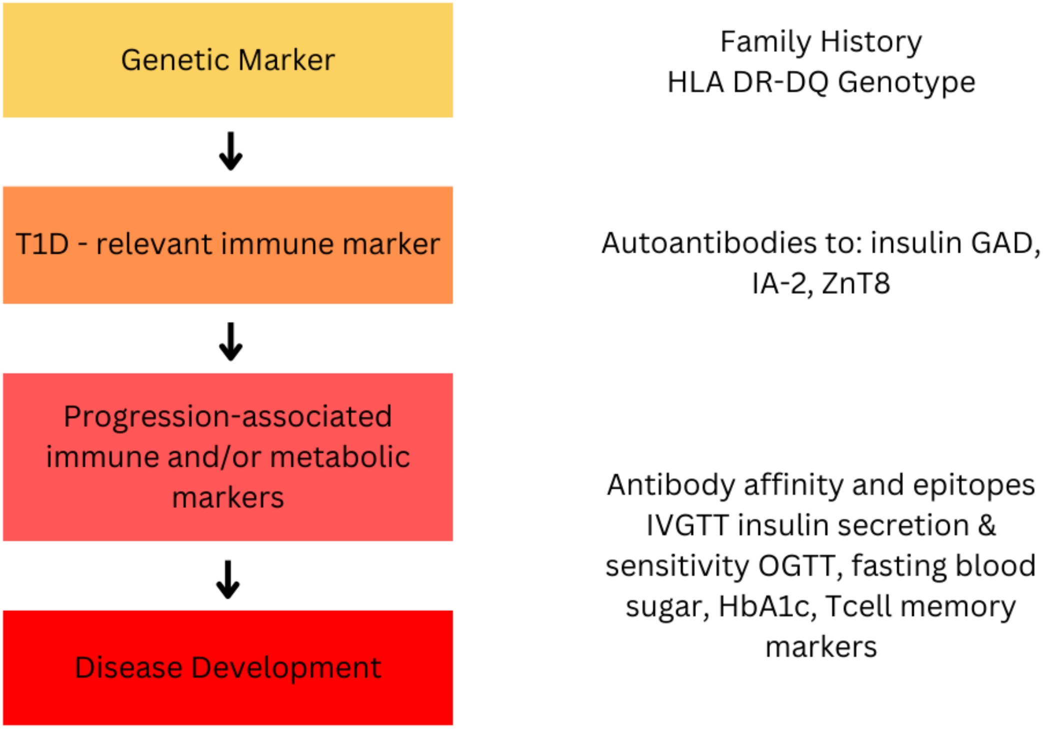
T1D is an auto immune disease that develops when the body attacks specific beta-cells in the pancreas (4). These cells generate insulin which is a hormone that regulates glucose levels within the bloodstream and is the main source of medication in an exogenous form to treat and manage T1D (5,6). During its development, the body proceeds to attack these cells and forces them to break down, eliminating one's ability to produce insulin and therefore regulate blood glucose levels (4,7,8). Historically, T1D was thought to develop in children and adolescents and therefore, was considered a disorder that predominantly developed among this population (7,9). Further research into this condition proved otherwise and more recently, it was recognised that T1D can also develop in adulthood (7). Being diagnosed with T1D involves taking a patient's fasting blood glucose and is highlighted as an indicator of the disease if it reads higher than 7 mmol/L (7). If fasting blood glucose reads > 11.1 mmol/L, this shows strong signs of hyperglycaemia and is treated with immediate action to avoid the risk of long-term implications, most commonly leading to the diagnosis of T1D (7). Early detection and appropriate management of T1D are crucial to prevent complications and promote better health outcomes. The onset of the symptoms of T1D can be immediate and in some cases, can develop over a longer period and therefore, is important to take signs of the disease seriously and essential to seek medical attention for potential diagnosis.

8.2 DIAGNOSIS AND RISK

In the early stages of diagnosis, signs and symptoms will largely consist of a combination of genetic and immunological features (10). Analysing these ‘immunological markers and genetic susceptibility traits’ constructs a detailed model of the pathogenesis of this disease, compromising a ‘sequential series’ of hindered homeostatic factors, supporting the individual’s immune system (10). Typically, being diagnosed with T1D consists of a wide range of symptoms that often develop unexpectedly and over a short period of time. Common symptoms of T1D include frequent urination, excessive thirst, fatigue, weight loss, blurred vision and mood changes (11). These symptoms are brought on by impaired transport of glucose from the circulation into tissues, which results in raised blood glucose levels, increased glucose in the urine and calorie and fluid losses (12). The diagnosis is made through blood tests for antibodies, glucose levels, and insulin deficiency (13).

Research has focused on the approaches to using a step-by-step decision tree to evaluate the level of risk associated with developing this disease. Initially, a genetic marker is analysed where family history is investigated for HLA class II genotype due to its presence indicating an increased likelihood of developing the disease (2,10). Secondly, those with a higher genetic risk will be directed towards measuring autoantibodies. According to the research from Zielger (10) et al, autoantibodies to insulin, GAD, IA-2 and ZnT8 will act as risk factors for developing T1D. Lastly, the patient will undergo the testing of beta-cell function where the ability of their body to clear glucose from their bloodstream is measured by testing the efficiency of their insulin response (10). Furthermore, recent research also states that the timing of the diagnosis will be indicated through the timing of the insulin response to glucose, therefore, the time of diagnosis may be prolonged and not immediately noticeable (10). Research from Katsarou et al (2), states that 70-90% of patients that are diagnosed with T1D, experience β-cell destruction and is categorised as the leading consequence of T1D, hindering one's autoimmunity. Despite this, a small percentage will experience insufficient evidence of this and tend to be diagnosed later in life (8). This group will tend to show a stronger genetic component compared to others and will lack the targeted autoantibodies, making it more difficult for an initial diagnosis (2).

Despite having known genetic causes, the majority of people with T1D do not have a family member who has the condition or even the highest risk HLA allele combination (14). This suggests anyone can be at risk of developing the condition. Regardless of significant advancements in patient health and survival, particularly during the past 25 years, a cure for T1D still unattainable and still in need of extensive research (14). With technological advancements and some integration into the healthcare system, many people with T1D do not have optimal glycaemic control, and many are unable to access modern therapies due to the high costs of even the most basic medical care (14).



8.2.1 Figure 1. Individual Stratification for Diabetes Risk Reflects Stages of Disease Progression **(14)**

8.3 HYPOGLYCAEMIA

T1D management is very dependent on the individual and the lifestyle that they lead. One of the main tasks that an individual with T1D must undertake is calculating the correct insulin-to-carbohydrate ratio. Metabolic health measures such as the blood lipid profile and HbA1c of an individual with T1D heavily influence their blood glucose control and insulin doses required. Good control is typically considered to maintain a blood glucose range of between 4.0 mmol/L and 10.0 mmol/L. T1D requires a high level of independence and 24-hour care. Continuous blood glucose monitoring systems significantly aid the management of T1D and are prerequisites for closed loop systems (5). Fear of hypoglycaemia is acknowledged as the most significant impediment to obtaining good glycaemic control, as this can be fatal (5). Experiencing hypoglycaemia is feared due to the recognition of the signs and symptoms that occur (6). Negative mood-state, increased tension, sweating, reduced energy, and salt-like taste around the lips are all characteristics experienced when blood glucose levels fall too low (15). In more severe cases, if too much insulin is injected at one time, blood glucose will drop so low that it will cause drowsiness and/or a diabetic coma (16). Similar to the difficulties associated with increased glucose regulation, exercise can significantly increase the risk of hypoglycemia in those with T1D (17,18). T1D may experience exercise-related hypoglycemia during, post-exercise, and several hours after a single session if the interaction between exercise and insulin is not taken into account and thus insulin dosing is higher than required, or carbohydrate supplementation has not been provided (17–22). Given the benefits of exercise, it is important that hypoglycemia risk factors be thoroughly understood by researchers, medical professionals, diabetes educators, and patients (23). Furthermore, it is imperative to devise efficient solutions and strategies to avoid unfavourable reductions in blood glucose levels while maintaining glycaemic regulation pre, during and post exercise (23).

8.4 HYPERGLYCAEMIA

Failure to accurately calculate one's insulin to carb ratio and not supplying enough insulin to level the blood glucose within the bloodstream will result in hyperglycaemia. Hyperglycaemia increases the risk of developing cardiovascular disease (CVD), with elevated mean HbA1c in T1D elevates such CVD risk (24,25). All signs and symptoms of T1D relate to hyperglycaemia: frequent urination, thirst, weight loss, fatigue, and visual impairment (25). Hyperglycaemia experienced by those with T1D is often associated with reports of 'acute and transient cognitive disruptions' (26). In more detail, disruptions are factors that may influence daily functioning and quality of life and if consistent, can result in long term complications, most commonly CVD (26). Previous research has shown significant visual impairment at a mean blood glucose level of 16.7 mmol/l and when comparing a healthy mean blood glucose for an individual with

T1D, there was a 9.5% reduction in fundamental performance at a higher mean blood glucose level of 20 – 30 mmol/l (27). The higher a patient's blood glucose level, the higher the demand for insulin to lower the amount of glucose in the bloodstream. The absence of insulin will increase HbA1c, therefore, encouraging the development of long-term complications like retinopathy, neuropathy, and nephropathy (28). The concentration of HbA1c indicates the long-term glycaemic control in both type 1 and type 2 diabetics, typically estimated from the previous three months of blood glucose measures (28).

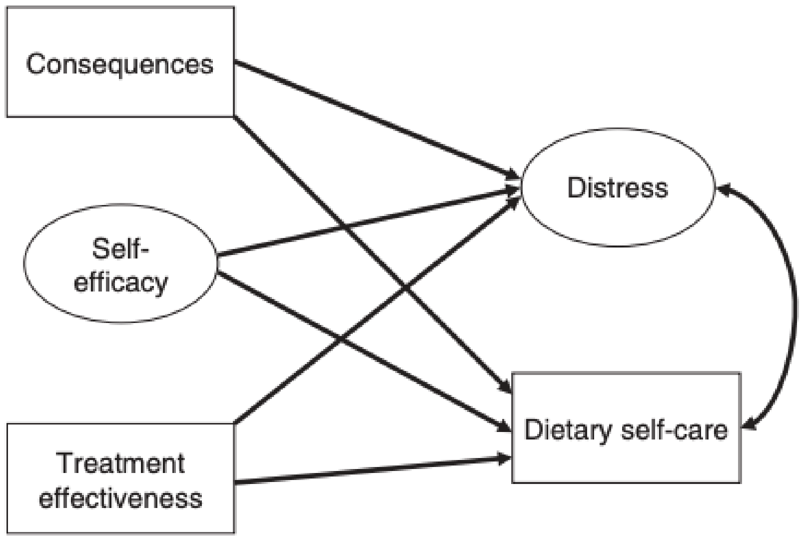
Modern diabetes treatment strategies aim to maintain blood glucose levels as close to 5.5 mmol/L as possible to lower the risk of both short-term and long-term complications (4). However, one of the most obvious aspects of T1D is how difficult it is for people to manage (4). This is particularly significant in young adults (4). Despite this, research suggests that this demographic, lack the attention from researchers and clinicians, almost considered as disregarded compared to their peers of an older and elderly age bracket (4).

8.5 MENTAL WELL-BEING/DIABETES DISTRESS MODEL

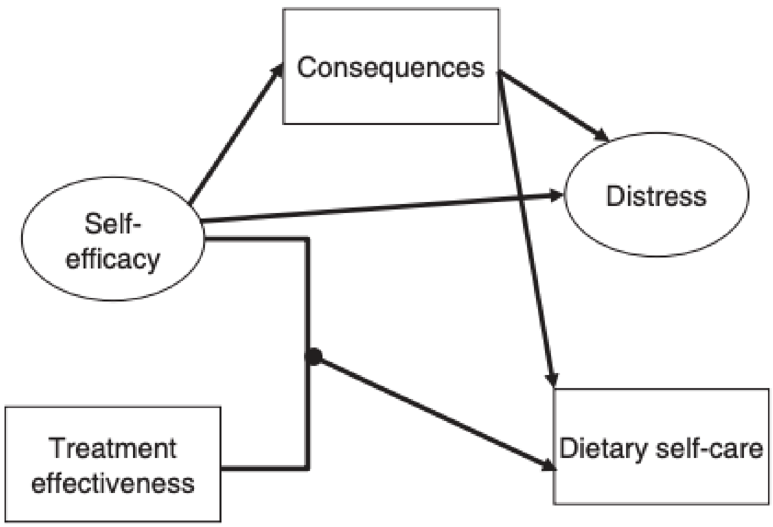
T1D patients have a high incidence of depressive disorders, with research estimating that 9 to 27% of diabetic patients experience depression at any given moment (29). In addition to having a detrimental impact on these patients' quality of life, depression has an impact on how the illness is managed and its repercussions (29). According to research from Stewart et al (29) , adult depressive patients reported a higher incidence of diabetes symptoms compared to diabetic patients without depression. Depressed patients also had inferior metabolic control and glycosylated haemoglobin levels were shown to be linked with the intensity of depression symptoms. Adults with depressive symptoms also had independent risk factors for heart disease (29). The same study noted that reasons for hospitalisation were in fact related to depression among those with T1D, highlighting the importance of mental well-being funding and provision.

Over recent years, the emotional demands of living with T1D have increasingly raised fears among professionals and those living with the condition, therefore, have been emphasized in research (30). Recognition of these psychological stresses come from the experiences an individual with T1D faces when managing their condition. The condition requires high levels of self-care and requires independence in terms of taking medication and testing blood glucose (30). The attention on the emotional side of T1D is a focus of the concept of diabetes distress (30,31). Diabetes distress is defined as the worries and struggles that come with managing life with T1D (30). It is frequently disputed that diabetes distress falls under the same description as various mental health conditions: depression and anxiety. However, this is not the case and is in fact more specific to the day-to-day experiences of a person living with T1D (31). The effects of diabetes distress directly affect both factors as it requires motivation and a proactive mindset in order to tackle the everyday practices of T1D (32). Research from Tareen et al (33), suggests that due to the strict regimen of diet and medication management, significant signs of behavioural rebellion emerge in all ages, whether that displays refusal of taking medication or bad behaviour in general. Significant research indicated that diabetes distress had impacted approximately 25% of UK adults with T1D (34).

The most frequent emotional problems endorsed by these individuals include worrying about the long-term risks, the fear of experiencing hyperglycaemia and hypoglycaemia (35). A major worry originates from the feeling of guilt associated with self-management and how one practices their daily routine with T1D (35). A strong correlation is represented when studying diabetes distress and depression (32,35,36). This research suggests that diagnosed clinical depression should be recognised through disease-related symptoms as well as considering the emotional well-being of an individual (32,35). Alongside other qualitative studies, the diagnosis of depression among those with T1D is often related to living with the condition (35).



8.5.1 Figure 2: Dietary self-efficacy, illness representations as independent predictors of dietary self-care and diabetes distress **(37)*.***



8.5.2 Figure 3: Self-efficacy interacts with (moderates) perceived treatment effectiveness to influence dietary self-care, while perceived consequences mediate associations between dietary self-efficacy and outcomes of dietary self-care and diabetes distress **(37).**

Figures 2 and 3 present the relationship between the factors associated with dietary self-care and distress in those with diabetes (37). Self-efficacy, consequences, and treatment effectiveness act as dependent variables against the independent variables: diabetes and dietary self-care. Figure 2 focuses on the association of the variables and how they act as predictors of the independent, whereas Figure 3 moderates with the perceived treatment effectiveness, influencing dietary self-care, while perceived consequences mediate associations between dietary self-efficacy and outcomes of dietary self-care and diabetes distress (37).

University students are commonly known as the 'forgotten group' among populations with T1D. It is recognised that the transition individuals experience when starting university is one which can be very stressful, especially for those with T1D who are very reliant on a routine lifestyle. Diabetes distress is evident in university students, highlighting feelings of loneliness and low quality of life (38). Life at university for students is stereotypically considered an exciting and challenging period but introduces time-management issues, changes to diet, stress, varied social situations and a rise in physical activity (39). Research from Beverly et al (39), suggests the demand for the assessment of diabetes distress due to these listed factors.

A vital component contributing towards mental well-being and supporting the immune system is sleep. Lack of sleep as well as poor quality of sleep are correlated with impaired glucose metabolism and insulin resistance, however, research is lacking on people with T1D (15). A study demonstrated between those with and without T1D and how their sleep characteristics differed from each other (15). Those with T1D had lower sleep quality and although the duration of sleep did not seem significantly different among both groups, overall, poor glycaemic control among type 1 diabetic participants demonstrated a worse quality of sleep (15).

8.6 NUTRITION

T1D is managed with a basal-bolus insulin regimen through numerous regular injections or continuous subcutaneous insulin infusion (40). Carbohydrate counting is a meal-planning aid and one that is a key component of managing T1D (40). This is based on knowledge of carbohydrates in meals and how they affect blood sugar levels (40). As part of learning to live with this disease, 'carb-counting' courses are offered to patients to allow them to gain extensive knowledge about a range of foods and how they will affect the body in day-to-day life and participating in physical activity. The total amount of carbohydrates taken at every meal and the insulin-to-carbohydrate ratio are used to calculate the necessary bolus insulin dosage (40). The insulin-to-carbohydrate ratio is a calculation that is unique to the individual and represents the number of insulin units that need to be taken in conjunction with the amount of carbohydrates consumed. There is evidence that carbohydrate counting may improve metabolic regulation and decrease levels of glycosylated haemoglobin (HbA1c) (40). Additionally, carbohydrate counting may lessen the incidence of hypoglycaemia as it creates accurate calculations as to what is consumed by the individual. Children and teenagers can manage their T1D more successfully within their own lifestyles due to a variety of meals and snacks. This supports this younger generation through reassuring their thoughts and feelings around the aspect of fitting in and being able to socialise, whether this means going out to eat or drink alcohol (40). The consumption of carbohydrates is a primary fuel source and should be tightly managed dependent on one's lifestyle. T1D in sport is highly reliant on the consumption of carbohydrates and will differ dependent of the intensity, duration and type of sport (41).

At all levels of physical activity, the human body requires various fuel sources. To reach optimum training effects and pose a positive impact on overall health and diabetes management, the consumption of carbohydrates and protein must meet the macronutrient needs of the individual (42,43). Diabetic athletes can often achieve glycaemic balance by increasing carbohydrate intake, without altering their insulin dosages (44). This commonly happens when performing short-duration activities more than 2-3 hours after taking fast-acting insulin (44). On the other hand, it appears essential in long-duration activities to begin exercising while blood insulin levels are sufficiently low as the elevation within physical activity will primarily use glycogen stored within the body as a source of fuel, lowering blood glucose levels (44). Physical activity and acting insulin levels will inevitably cause hypoglycaemia, especially without the sufficient consumption of carbohydrates; however, due to the nature of the event, athletes may not eat sufficient carbohydrates due to difficulties in the ingestion during competition and/or a lack of knowledge about optimal fuelling strategies.

Research from Gallen et al (42), suggests that there are no current recommendations for daily macronutrient consumption of athletes with T1D. A general recommendation from the same study suggests that an athlete should consume 30-60g of carbohydrates per hour of exercise, but requirements can vary depending on the intensity, duration and type of exercise (42). Athletes who follow unhealthy eating habits and/or habits that do not fit the recommended norms of producing peak performance can produce negative effects (45). Additionally, female athletes have to be mindful of nutritional concerns such as amenorrhea, osteoporosis, eating disorders and the potential disadvantages of fast weight loss to "make weight" (45). Neglecting the act of taking insulin is a widespread occurrence for T1D athletes in weight-classified sports including wrestling, boxing, and weightlifting as the absence of insulin will cause the body to crave a form of fuel (45). The most plentiful stored energy comes from the fat inside the body, however, withholding from taking insulin leads to high blood glucose levels (45). If made into a habit, it will cause long-term implications for the individual and potentially negative, life-long consequences (45).

8.7 SPORT AND EXERCISE

One of the most significant problems for athletes with T1D is optimising performance while minimising disruption to achieve optimum blood glucose management (46). Exercising is frequently more challenging for individuals who take insulin because muscle contractions can enhance blood glucose uptake independently of insulin, resulting in hypoglycaemia (46). The use of exogenous insulin therapy is unique to the individual, especially concerning their body composition measurements due to the presence of body fat, inhibiting the efficiency of insulin entering the bloodstream. Exercise is recommended to individuals with T1D to improve and maintain good blood glucose control with the benefits outweighing the risks (47). When working with T1D athletes, it is encouraged to be aware of overly critising their performance because it is common for them to blame their condition which in-turn affects overall levels of confidence as well as general thoughts and feelings about being an athlete with T1D (47). Research from Jimenez et al. (16), states that ‘the most difficult aspect in dealing with these patients is providing education and insight into their disease process’ and that ‘these athletes should be allowed to take ownership of their condition and encouraged to take an active role in their treatment’. Benefits of exercise for an athlete with moderately controlled T1D, facilitates the overall muscle mass development as insulin will utilise amino acids sufficiently within the bloodstream (47). Studies have found that exercise will reduce cardiovascular risks associated with the condition as well as encourage higher self-esteem and confidence in athletes (47).

When compared to inactive patients, active adults with T1D have a greater likelihood of attaining target HbA1c levels, blood pressure levels, and a healthier BMI (48). Regular exercise also minimises total daily insulin demands (48). In individuals with and without T1D, having a high exercise capacity in adulthood is linked to a lower chance of coronary artery disease, myocardial ischaemia, and stroke (48). Research from Riddell et al (49), briefly described the dominant energy systems concerning an individual suffering with T1D and the typical response to physical activity compared to an individual without. Hyperinsulinemia heightens complications when aiming to achieve optimum sporting performance (49). Exercising for a T1D results in the need for potential insulin-dose reductions to avoid hypoglycaemia as typically, when exercising, whole-body glucose utilisation increases as well as overall absorption rates (49). This alteration can then lead to hyperglycaemia, creating a negative long-term affect for T1Ds, e.g., encouraging the development of cardiovascular disease (48,49). Research has also considered typical characteristics of elite athletes, one being competitiveness which can encourage unhealthy dietary patterns, exercise resulting in extreme exhaustion and use of ergogenic aids and illegal substances (49,50). This behaviour is dangerous for those suffering with and without T1D but can also negatively impact one's mental state (49,50).

A significant consideration is the knowledge that the athlete has of their chosen sport and the type of energy expenditure that the specific activity requires. Therefore, the more knowledge an athlete has of the nature of the sport, the better they will be able to plan their dietary requirements around their performance. Relevant factors include the anaerobic or aerobic components of the sport, exercise intensity when training and when in competition, exercise duration and the risks they may experience around having T1D i.e. what is the scenario if the athlete experiences hypoglycaemia (45). The athlete with T1D must be conscious of the effects the disease has on their total body and undertake personal responsibility for managing their glucose levels on a regular basis (45).

In the initial stages of exercise, the muscles’ primary source of fuel to function efficiently is glucose and this originates from glycogen stores, but also includes the production of glucose through hepatic glycogenolysis and uptake from exercising the muscles (42). A T1D athlete must carefully monitor the effects of exercise on blood glucose levels. Focusing on the type, duration and intensity of exercise performed, it is common for a T1D athlete to experience hypoglycaemia if the correct precautions are not monitored throughout practice (42). The inevitable occurrence of experiencing hypoglycaemia during or following vigorous activity derives from an increased insulin absorption, reduced catecholamine responses and impaired glucagon secretion (42).

Exercise can be categorised as aerobic and anaerobic. Both forms of exercise utilise blood glucose as an energy source when performing physical activity (51). In people with T1D, continuous, moderate-intensity, aerobic exercise tends to result in hypoglycaemia (43). The drop in blood glucose concentration is predominantly due to the failure of one's ability to lower insulin levels at 'the onset of continuous exercise' (43). The body will not respond to exercise typically compared to a non-diabetic athlete and the response will inevitably result in impaired glucose production and elevated rates of glucose disposal, therefore, encouraging the occurrence of hypoglycaemia for the diabetic athlete (43). Biochemical hypoglycaemia (i.e., blood glucose < 4 mmol/l, with or without symptoms) can also occur shortly post-exercise and again 7-11 hours later in recovery, most likely due to a 'biphasic change in insulin sensitivity post-exercise' (43). However, not all forms of exercise result in hypoglycaemia.

Blood glucose monitoring is highly important during exercise due to the physiological complications experienced. It is recommended that blood glucose should be monitored every 30 minutes of exercise but for some, this is not realistic, and recommendations then state it should be checked at least twice across the whole course of exercise (47). However, these recommendations have been made achievable through the use of continuous blood glucose monitoring (CGM) (52–54). To gain a better knowledge of the long-term impacts of exercise on glucose response, CGM devices were primarily employed to analyse and optimise diabetes management pre-, during and post-exercise blood glucose levels (52–55). CGM can monitor short-term fluctuations in glucose concentration even in a variety of glycaemic situations (hypoglycemia and hyperglycaemia), which may reflect those seen during physical activity (53,54). Healthcare professionals can better tailor strategies to physical activity based on individual responses as real-time CGM becomes more available and affordable (54). Testing regimes will be individualised depending on the form of exercise. Recommendations will be very dependent on the prior measurements taken before taking part in exercise and this may result in the athlete having to stop performance altogether to control their management (47).

Physical activity has been shown to have positive effects on individuals with T1D, including improved insulin sensitivity, decreased risk of cardiovascular disease and better mental health and well-being (56,57). However, being an athlete or a physically active individual with T1D comes with its complications as exercise has a significant effect on blood glucose levels. Additionally, high-level performance requires carbohydrate fuelling which can impact blood glucose levels, therefore, insulin doses must be adjusted accordingly. Despite these challenges, exercise has a beneficial effect on overall management of T1D and can help to improve overall health and well-being of individuals with T1D (58). Recognising the effects of food, drink, exercise, and stress in T1D is particularly important during times when other social support mechanisms are adapting, such as during the transition from home to university (59). A study from Rasmussen et al. (59), reported that a negative outlook on one's body image affected overall management which is proved a common pressure for athletes generally due to the stigma of looking a 'certain way'. Furthermore, another pressure for T1D athletes is coping with illness. The nature of the illness being an auto-immune disease, makes it increasingly difficult to fight off illness and therefore, affecting other factors in their lives such as performing in physical activity (59). Additionally, the same study showed that results indicated diabetes management being frequently perceived as a lesser concern for participants during transition periods, which can have serious consequences for their health (59).

8.8 The Type 1 Diabetic Athlete: Advantages and Disadvantages

In a T1D athlete, hypoglycaemia may develop during or after exercise (45). Due to insufficient calorie intake to fulfil metabolic needs, immediate hypoglycaemia most frequently occurs during or shortly after exercise in T1D athletes. Other factors include administering large amounts of exogenous insulin, injecting insulin into the area of a muscle that is exercising, or surrounding subcutaneous tissue, which enhances the rate of absorption (45). While hyperglycaemia does not result in the athlete stopping exercise, over the longer term, both performance and health can be compromised (25). High-intensity exercise will increase catecholamines, free fatty acids and ketone bodies which are all substances that contribute towards impaired the utilisation of glucose in the muscles as well as increasing blood glucose levels (25). Additionally, most athletes will experience some sort of psychological stress whether it is concerning the competition or related to external reasonings. This stress will cause a rise in blood glucose levels, meaning the athlete will face unpredictable hyperglycaemia which presents a high risk in the attempt to control with increased insulin dosages (25).

It is important to understand the risks associated with training as a T1D athlete. Research from Jimenez et al (25) suggests a plan concerning the management of T1D athlete in order to project a broader understanding so that these athletes are provided with equal opportunity when it comes to physical activity and performing at a high level. The diabetes care plan should be assigned for training and competitions (25). A list of the type of medication used for diabetes management, blood glucose targets, exclusion thresholds, strategies to prevent exercise-associated hypoglycaemia, hyperglycaemia, and ketosis, signs, symptoms, and treatment guidelines for hypoglycaemia, hyperglycaemia, and ketosis, and emergency contact information should all be considered when putting the diabetes care plan in place for the athlete (25). To treat hyperglycaemia, the preferred recovery methods and equipment should be of easy access to avoid any emergency concerning the athlete's low blood glucose (25). The sports trainer and/or other members of the diabetes care team, such as the coach, must have quick access to the equipment in case the athlete needs assistance (25).

8.9 Transitioning From Home to University

The transition period from home to university is a common event. For all students, not just those with T1D, the academic experience qualifies as a significant life event and one in which needs more recognition and attention (60). For university students to successfully adjust to university life, psychological well-being is a significant factor (61). Transitioning from home to university is a process that is a huge factor in well-established habits and routines being adapted to a new environment that has been in place for the majority of one's childhood (62). It is frequently reported that this period of life is an overwhelming experience that heavily impacts the individual's mental well-being and one that should be supported throughout the duration. Research from Pokorny et al (63), suggests that it was estimated that 10-15 % of students in their first year of university failed to feel settled into university life. A range of factors contribute towards the thoughts and feelings around attending university and whether students are happy within including finances, gender, social skills, location and culture (63). Establishing new connections with peers, roommates, and other members of the campus community constitutes one of the major social barriers (60).

University, however, often comes with additional stressors for individuals with T1D. This new environment presents extraordinary changes in one's lifestyle compared to a previous life with parental involvement, sense of routine, supporting networks and no financial worries (3,4), such as challenges in having access to medical professionals and clinics and feeling comfortable and familiarised enough to regularly attend appointments and prioritise their health (60). T1D patients report having more regular blood glucose tests and insulin requirements while attending university due to the change in lifestyle and timetable (60). Therefore, despite the significant challenges of university life, T1D students are vulnerable to adopting bad habits associated with diabetes management due to the desire of wanting to fit in and accommodating to university life including activities such as socialising with friends, nights out, eating out and disrupted sleeping, eating and drinking patterns (60). The transition will from home to university will likely negatively impact diabetes management and therefore emphasises the difficulties for this group of individuals when adapting to this environment.

8.10 SUMMARY

Within this chapter, we can highlight that the university lifestyle has a big impact on athletes with and without type 1 diabetes. University life for athletes frequently results in greater academic and social expectations on top of schedules for training and competition. For university athletes with type 1 diabetes, these difficulties are made worse by the need to manage extra complications such as blood sugar regulation, insulin delivery, and dietary issues. The complexity of managing their diabetes requires constant monitoring and modifications, which further complicates their academic and social experience. However, they can thrive in both academics and athletics and effectively navigate the university lifestyle with the right help, knowledge, and proactive management.

2

The Impact of University Lifestyle on The Health, Well-being, and Performance of University Athletes

9 THE IMPACT OF UNIVERSITY LIFESTYLES ON THE HEALTH, WELL-BEING, AND PERFORMANCE OF UNIVERSITY ATHLETES

9.1 ABSTRACT

Purpose: This study investigated the impact of university lifestyle on a student athlete's health, well-being, and performance, as well as explored the differences between university athletes with and without T1D. Additionally, the study looked at the students' mental health, physical health, sleep quality, and dietary management using validated questionnaires and prepared questions, conducting research into the quality of life led by university students. **Methods:** A descriptive study was conducted utilising four validated questionnaires DSMQ, PHQ-9, PAID, and IPAQ. Additional questions assessed factors related to physical activity, nutrition, sleep, and mental well-being. 98 athletes (height 1.7m ± 0.1, weight 75.2kg ± 15.9 and BMI 24.9 kg/m2 ± 4.2) were recruited. Participants were University students who regularly participated in PA, and were divided into T1D and non-T1D university athletes. **Results:** T1D university athletes (n=6) reported higher vigorous and moderate levels of physical activity compared to non-T1D university athletes (n=92). Non-T1D university athletes reported a higher prevalence of depressive symptoms compared to those with T1D. T1D university athletes identified ‘Glucose Management’ as a key problem area within diabetes management. **Conclusion:** There was a high percentage of university athletes who did not meet the recommended guidelines within physical and mental health testing. Separating test groups, T1D conformed to the guidelines more so than non-T1D university athletes. The small sample size was highlighted as the predominant limitation.

Keywords: Type 1 Diabetes, physical activity, mental well-being performance, university athlete

9.2 INTRODUCTION

Regular physical activity (PA) and exercise are important in promoting and preserving overall health and well-being (64). Despite widespread awareness among university students about the benefits of PA and structured exercise, previous research has shown that the majority of students fail to incorporate an adequate amount of exercise to maintain or enhance their health and fitness throughout their first year of study (64). This is concerning because behavioural patterns established during the university years tend to persist into adulthood, influencing perceptions and attitudes toward the importance of PA (62,64,65).

9.3 PHYSICAL ACTIVITY LEVELS

PA is defined as 'any bodily movement produced by skeletal muscles that results in energy expenditure' (66–68). PA is an important aspect of leading a healthy active lifestyle, positively impacting an individual's physical and mental health (69). Being physically active is identified as engaging in regular physical activities and exercise, requiring more energy than rest (67,68). Conversely, being physically inactive is defined as not meeting the recommended levels of PA to maintain good health, involving minimal physical activities and exercise (67,68). Current guidelines state that moderate aerobic physical activity (MPA) should be performed at least 5 days per week for a minimum of 150 minutes or vigorous aerobic physical activity (VPA) should be performed at least 3 days per week for at least 75 minutes or an equivalent combination of both (68,70). Participating in PA will bring noticeable benefits, specifically around the reduction of the development of underlying health conditions such as coronary heart disease, diabetes, hypertension, obesity, osteoporosis, cancer, and cardiovascular disease (71,72). Regular PA improves body composition, autonomic tone, glucose homeostasis, and insulin sensitivity (4), mental health, muscle, bone, and joint health (66,70,71). Current research suggests that almost one-third of the world's population is not sufficiently active (70).

With a substantial health impact, research proposes that if the global population met the current guidelines for PA, it would remove 6-10% of cardiovascular diseases: the leading causes of death internationally (73,74).

Data concerning the comparison of PA and lifestyle habits between non-student and student groups is limited. However, students have recently attracted researchers' attention due to 'unique characteristics' during their transition from home to university (75). Levels of PA during the first few months of university can be negatively affected by the changes in lifestyle patterns and having to carry out new activities such as washing, cleaning, and cooking (62). These patterns may result in reduced PA habits that the students will carry through years of studying at university and into later adulthood, potentially leading to longer-term negative health consequences (62,64).

Students form a particular subgroup during their introduction to university life. Consequently, depending on whom their initial social relationships are built with and/or the habits they carry over to the university, these influential factors will shape the decisions that students make about how they want to conduct university life. Sedentary behaviour such as attending lectures and laboratory sessions is a hallmark of students' everyday lives; nonetheless, physical exercise is considered crucial for this age group since it sets the foundation for future health patterns (76). Additionally, obesity brought on by this age group's lack of PA might have long-term health consequences not only on themselves and their peers but also on organisations such as the NHS (76). When students transition into university life, they are commonly already physically active or want to join a social/competitive club for leisure and/or to begin a new hobby. However, a high proportion of students lack interest or time when it comes to starting a sport or participating in a form of PA, prioritising their studies and, in turn, neglecting a healthy active lifestyle (77).

A range of health factors will affect the way that students lead their typical university lifestyle. These factors can include anything from allergies and intolerances to mobility issues and abnormalities in mental and physical functioning (78). The majority of students will start university having experience in the participation of PA and will partake in sports as an extra-curricular activity alongside their studies (79). For the purpose of this study, a university athlete is defined as an individual who regularly participates in PA and attends university and includes those from an amateur through to an elite/scholar level.

9.4 MENTAL WELL-BEING

Globally, it is estimated that 350 million people are affected by depression (80). The mental well-being of university students is a growing concern and the population itself has been emphasised as a 'very high-risk population' for 'psychological distress' and 'mental health disorders' (81–83). A previous survey of 5000 students looked at the mental well-being of university students and results demonstrated that 84% of participants experienced increased levels of psychological distress, and 13% of participants reported severe or extreme anxiety symptoms (81). Poor mental well-being among university students has a large impact on several aspects of their cognitive, physical, interpersonal, and emotional functioning, hindering not only their academic motivation but also their performance (81). Previous studies have investigated the risk factors for the decline in the mental well-being of university students. The 'peak onset' of mental health disorders is before the age of 24 (83,84); this is significant because people in the UK can start university from the age of 18. This conclusion has been drawn from the considerable research on the difficulties university students experience through the transition to adulthood, originating from making new friends, adapting to new methods of learning, handling finances, and increased workloads (83). Furthermore, in the UK the number of students attending university has grown significantly, and larger groups within courses can make it harder for first year students to make new friends and 'settle in' (83).

The act of participating in sports at university is an invaluable undertaking among university students, supporting both the physical and mental health (85). Academic and non-academic pressures usually exacerbate stress for students, especially within their first year. As a result, encouraging students to participate in PA can help reduce students' stress levels and increase their psychological well-being and overall happiness (85). Previous studies have focused on the key motivators behind participating in PA for university students; such factors commonly consist of benefits concerning health, the aspect of having fun as well as socialising with others (76,86,87). Participating in PA as a student has further benefits beyond the aforementioned: it can develop physical and motor skills, build social skills, encourage new friendships, and is effective for adaptability, considering the transition into a new environment (88). Research from Yanik et al (88) suggests that each of these benefits will heavily depend on the attitude of the student due to its 'powerful effect' on an individual's behaviour.

9.5 NUTRITION

Achieving good health, sufficient energy sources, and growth comes from basic nutritional needs (89). During the transition period in which students are adapting to their new lifestyle and environment, they are susceptible to negative health behaviours (90). While a strong emphasis on the importance of meeting nutritional requirements is taught from primary education age, university students often do not prioritise behaviours of good eating habits, obtaining health, and providing optimal function (91). Previous studies investigating the eating behaviours of university students have reported that they fail to consume the recommended amount of fruit and vegetables, instead, over-consuming fatty foods (90,92). Consequently, if students cannot adequately fuel themselves with a balanced diet, a decrease in academic and/or physical performance may occur (91).

University students regularly face barriers that hinder their ability to achieve an optimal diet: lack of time and space to prepare meals, low financial resources, lack of knowledge around meal planning and cooking, and busy training and travelling schedules for those who are university athletes (93). As a result, many undergraduate students will opt for takeaway food (91). Research from Salama et al (94) reports that good eating habits for undergraduates positively correlate with nutritional well-being and prevent illnesses specifically related to poor nutrition. Certain sports at universities may lack coaches or other professionals to advise athletes on how to optimise their performance through good nutritional behaviours, leaving students to rely on their knowledge which may not be adequate for their lifestyle (95).

9.6 SLEEP

Essential human functioning, physiology, cognitive and physical recuperation depend significantly on the quality of one's sleep (96). Sleep is a 'homeostatically controlled behaviour' that is defined as a 'state of reduced movement and sensory responsiveness' (97). Research states that sleep plays an essential role in metabolic homeostasis (97,98). Over the course of 24 hours, the human body will alternate between states of wake and sleep (99–101). The fluctuation of sleep allows the body to recover from the previous activity within the day, allowing a person to feel refreshed and alert (99). Prior research has shown that sleep deprivation can have a serious detrimental effect on mood, cognitive functioning, learning, memory, speed of response, reaction time, and auditory alertness (96). Inadequate sleep has been demonstrated to affect the metabolism, and the endocrine system as well as heighten perceived exertion during exercise, negatively affecting performance outcomes (96,98). According to the National Sleep Foundation, young adults (18 to 25 years old) should aim to achieve between 7 and 9 hours of sleep every night (98). In a study of elite athletes from a variety of sports, it was indicated that this demographic requires approximately 8.3 hours of sleep per night to feel rejuvenated and able to produce peak performance (98).

Sports performance relies heavily on a balance of cognitive, physiological, and physical outputs (99). Compared to those at university who do not regularly partake in PA, university athletes may require more sleep due to the increased need for recovery from the stresses of training and competing (99,102). Research from Halson et al (99,103) reports that sleep has been suggested as the 'best recovery strategy' for an athlete. This study states that sleep will reduce inflammation, pain, as well as regulate body temperature; these are all factors that aid recovery and increase the probability of reaching peak performance (99). University students do not always prioritise their sleep and can form bad habits in their sleeping patterns (104). Research from Brown et al (104) indicates that 1/3 of university students reported regular disturbances and sleep difficulties. The other 2/3 reported occasional issues concerning their quality of sleep such as irregular sleep patterns due to working late and/or later timetables. Other factors that have been researched, and noted, as causes of disrupted sleep include irritability, depression, confusion, increased tension, and lower quality of life satisfaction (105). While it is common to blame the poor quality of students' sleeping patterns on excessive late-night socialising and a lifestyle containing the use of drugs, alcohol, and smoking, this is not the case for all students. Consequently, the priorities and lifestyle choices of such individuals will vary (104,105).

9.7 TYPE 1 DIABETIC UNIVERSITY ATHLETES

Type 1 diabetes (T1D) is an autoimmune disorder that is characterised by a deficiency of insulin and increased hyper- and hypoglycaemia (14). People with T1D are still able to accomplish their athletic goals and careers regardless of the barriers they face concerning the management of their condition (46). Several athletes with T1D compete from amateur to elite levels in an array of sports while simultaneously successfully managing their diabetes (46). However, this is not simplistic nor universal. Due to the nature of the condition, university athletes with T1D often experience difficulties in controlling their blood glucose levels while engaging in sports and balancing their academic responsibilities (106). For consistent, in-range blood glucose levels to be maintained, and for performance and general health to be maximised, glucose management must be carefully controlled in everyday life (51,106,107). Advances in medicine have reduced the pressure on those with T1D. As a result, there are now several ways to optimise diabetes management without having to independently manage the condition 24/7 (107).

During exercise, the body produces energy primarily through aerobic and anaerobic pathways (47). Aerobic exercise works to generate sufficient energy and involves utilising one's oxidative metabolism through sustained, rhythmic movements of large muscle groups for at least 10 minutes (47). Anaerobic exercise relies on nonoxidative metabolism and is characterised by resistance-type activities (47). For a T1D athlete, anaerobic, short-distance, sprint exercise events typically result in issues with metabolic and diabetes management (45). Acute catecholamine (physical/emotional stress hormone) release in certain athletes may result in hyperglycaemia, however, prolonged hypoglycemia is uncommon (45).

During PA, many athletes with T1D utilise continuous glucose management (CGM) devices to continually monitor their blood glucose levels. CGM devices typically include a ‘small pager-like monitoring device’ that receives signals from a sensor inserted into the subcutaneous layer (108,109). CGM provides 'real-time' data, meaning that patients are aware of their blood glucose levels throughout the day without having to consistently take finger-prick samples (110). Due to the advancement in technology allowing them to follow their levels more closely, athletes can be responsive in modifying their insulin levels and carbohydrate consumption (108). Research from Bowler et al (109), states that despite the advancement in technology, especially those with conditions including T1D, there are several limitations concerning the use of CGM. These include ‘CGM sensor durability, software design, usability, and influences of external environmental variables, such as the immersion of the CGM in water, extreme climatic conditions, high sweat rates, and direct physical contact with others’ (65). However, the benefits of using CGM for T1D outweigh the negative implications because CGM’s real-time data allows diabetics to optimise their blood glucose management. They do this by adjusting insulin doses as well as supplying their medical professionals with more data to help the individual better their management around PA and dietary intake (109).

9.8 Aims and Objectives

The purpose of this study is to investigate the impact of university lifestyle on a student athlete's health, well-being, and performance, as well as to explore the differences between university athletes with and without T1D. Despite the significant changes that students inevitably face while at university, research on how they are affected by being detached from their usual supervision is limited. Additionally, if these students are athletes and enrol in university to participate in sports, there is a need to investigate how they have additional concerns and pressures may be affecting their health. Physical and mental underlying health issues are becoming more prevalent among the younger generation who attend university, emphasising the need for support. The study will look at the students' mental health, physical health, sleep quality, and dietary management using validated questionnaires and prepared questions to conduct research into the quality of life led by university students. It is hypothesised that students with underlying health concerns will be more conscious of the repercussions of neglecting one's general health thus leading to a healthier, more active lifestyle.

9.9 METHOD

9.9.1 Participants

Students who attend UK Universities and regularly participate in PA were invited to participate in the study through social media platforms. Initially, 159 athletes agreed to participate and started the survey, however, 61 surveys were removed as they were incomplete. A total of 98 completed responses were obtained (height 1.7m ± 0.1, weight 75.2kg ± 15.9 and BMI 24.9 kg/m^2 ± 4.2). All participants gave informed, written consent before completing the survey. The study was approved by the University of Essex Ethics Sub-committee 2.

9.9.2 Study Design

A descriptive study utilising four validated questionnaires: Diabetes Self-Management Questionnaire (DSMQ), Patient Health Questionnaire (PHQ-9), Problem Areas in Diabetes Questionnaire (PAID) and International Physical Activity Questionnaire (IPAQ) and a series of supplementary questions were used. Surveys were completed using an online software (Qualtrics, Provo, UT). Questions included age, self-reported height, and weight, physical activity, nutrition, sleep, and mental well-being. Questionnaires were self-reporting and may pose errors in measures when analysing results. Participant information was provided at the beginning of the study and consent was obtained before commencing the study.

9.9.3 International Physical Activity Questionnaire

The IPAQ includes a set of four questions that investigate the intensity of exercise and the total duration that each participant spends within those intensities. The IPAQ had four subsections regarding intensity and duration of exercise in a typical week: vigorous, moderate, walking, and sedentary. The purpose of the questionnaires is to provide subjective responses regarding everyday life that can be used to obtain internationally comparable data on health-related PA (111). The complex, self-administered IPAQ measures the intensities of PA: vigorous, moderate, and walking. Indicators of sedentary behaviour such as the amount of time spent sitting are also covered in the questionnaire (111). The number of days per week and the amount of time per day spent engaging in vigorous and moderate exercise are tracked for each of the four areas. Walking time is also accounted for during work, travel, and free time (111): these subsections are measured in hours and minutes.

9.9.4 Patient Health Questionnaire

The PHQ-9 is a 9-item depression module that originates from the full PHQ. The questionnaire was scored on a severity scale measuring the level of depression based on the data collected from participants. Major depression is diagnosed if 5 or more of the 9 depressive symptoms are indicated within the questionnaire. Participants were scored using a Likert scale where scores are then added up to create a total value. The scale is split into five subsections, categorizing the total scores for each participant: Minimal (0-4), Mild (5-9), Moderate (10-14), Moderately Severe (15-19) and Severe (20-27).

9.9.5 Diabetes Self-Management Questionnaire

The DSMQ is a 16-item questionnaire used to analyse the self-care activities associated with glycaemic control and diabetes management (112). All participants who declared that they were T1D completed this validated questionnaire. The questions are worded as behavioural descriptions and are presented from a diabetic patient's point of view. They are placed on a scale where participants rate the extent to which each description applies to them on a four-point Likert scale (3 – 'applies to me very much' to 0 –'does not apply to me') (113). The data is scored by splitting the 16 questions into 5 subsections: Glucose Management (1,4,6, 10 and 12), Dietary Control (2, 5, 9, and 13), Physical Activity (8,11 and 15), Health-Care Use (3, 7 and 14) and Sum-Scale (Total). Scale scores were calculated as sums of item scores, divided by the maximum total score from the questions associated with each subsection. Following this, the score was then multiplied by 10 to achieve a final score on a scale of 1 to 10. The equation as follows, raw score / theoretical maximum score * 10.

9.9.6 Problem Areas in Diabetes Questionnaire

The PAID questionnaire includes 20 questions that cover a range of emotional states frequently reported in Type 1 and Type 2 diabetes (114). The questionnaire produces a total score ranging from 0 to 80, where a higher score indicates greater emotional distress and highlights concern in one's condition (114). The PAID uses a 5-point item scaling: 'Not a problem' = 0, 'Minor problem = 1', 'Moderate problem = 2', 'Somewhat serious problem = 3', and 'Serious problem = 4'. The 0–80 total score is attained by adding the 0–4 responses given for the 20 PAID items. A 6-point item scaling was originally used for the PAID as well as raw item scores, but this was simplified to provide the current item scaling and scoring (114). When interpreting the results, each score is categorised in terms of the severity of distress: 0-20 = Little to no distress, 21-40 = Moderate distress, 41-60 = High distress and 61-80 = Very high distress. A high score on the PAID scale suggests that the person may benefit from additional support, education, or interventions to address their emotional and psychological well-being related to diabetes. To generate a total score, the values for each response are totalled and then multiplied by 1.25. A total score above 40 indicates a need for concern for the individual and to discuss issues with a professional (115).

9.9.7 Nutrition

Participants were asked a series of questions, designed by the researcher, regarding their nutritional behaviour at university. They were asked to construct a rough summary of what they would typically consume throughout the day, including examples of snacks and typical meals. They were also asked if they were aware of the nutritional constituents of the foods that they would normally eat. An example of one key question asked to the participants was, ‘What food group does your diet mainly consist of?’. Four options were given in the form of a multiple-choice question: Carbohydrates, Proteins, Fats, and Vitamins and Minerals. The frequency of each response was recorded within an Excel Workbook.

9.9.8 Sleep

Participants were asked a series of questions regarding their sleeping patterns and quality of sleep at university. These questions targeted the duration of sleep an individual would typically receive as well as investigated stereotypical behaviours of a university students i.e. frequency of socialising and drinking alcohol. The question ‘How much sleep, on average, do you get each day?’ is a key example of one of the questions asked. The multiple-choice answers ranged between <5 hours to 9+ hours. Another example of a question posed to the participants was ‘Regarding the university lifestyle, what is the main factor contributing towards your tiredness?’. The answers that were selective choice were ‘Attending lectures and seminars’, ‘going out and socialising’, ‘travelling’, ‘assignments’, and ‘other’. The frequency of each response was recorded within an Excel Workbook.

9.9.9 Statistical Analysis

Data was inputted in an Excel Workbook (Microsoft® Excel® for Microsoft 365 MSO, Version 2311 Build 16.0.17029.20028) and checked for erroneous data input. Participants were split into those with T1D (n=6) and those without T1D (n=92). The mean and standard deviation (M±SD) values for the anthropometric measures were calculated and put into a table to profile the sample group. All questionnaires were scored individually, and the data was placed into tables. Data are reported as mean and standard deviation (M±SD) values.

9.10 RESULTS

Participant demographics are shown in Table 1.

9.10.1 Table 1: Mean (M) and Standard Deviation (SD) of Participant Anthropometric Measures (n = 98)

	Total Participants (n = 98)	*Type 1 Diabetics (n = 6)*	*Non-Type 1 Diabetic (n = 92)*
Height (m)	1.7 ± 0.1	1.8 ± 0.1	1.7 ± 0.1
Weight (kg)	75.2 ± 15.9	68.9 ± 12.5	63.5 ± 15.9
BMI (kg/m^2)	24.9 ± 4.2	22.4 ± 2.6	25.1 ± 4.2

9.10.2 Table 2: Mean and Standard Deviation of IPAQ Questionnaire Results

		Mean & Standard Deviation of All Participants (mean ± SD) (n = 98)	***T1D University Athletes (mean ± SD) (n = 6)***	***Non- T1D University Athletes (mean ± SD) (n = 92)***
Vigorous Activity	***Days per week***	3.3 ± 1.5	4.0 ± 0.6	3.2 ± 1.6
	Minutes per day	83.0 ± 52.9	95.0 ± 74.3	82.2 ± 50.5
Moderate Activity	***Days per week***	2.7 ± 1.8	3.3 ± 2.3	2.7 ± 1.7
	Minutes per day	63.1 ± 81.4	90.0 ± 138.6	61.4 ± 78.9
Walking	***Days per week***	5.8 ± 1.7	6.2 ± 0.9	5.8 ± 1.7
	Minutes per day	92.5 ± 102.9	73.3 ± 76.1	93.8 ± 102.3
Sedentary	***Minutes per day***	235.1 ± 174.8	205.0 ± 154.4	237.1 ± 176.8

9.10.2.1 Physical Activity – IPAQ Questionnaire Results

Results from IPAQ can be seen in Table 2. T1D had the highest values for vigorous activity: (4.0 days per week ± 0.6) and (95.0 minute per day ± 74.3). T1D also had the highest values for moderate activity: (3.3 days per week ± 2.3) and minutes per day (90.0 minutes per day ± 138.6). Additionally, T1D had the highest values for walking activity: (3.3 days per week ± 2.3) however, non-T1D reported the highest values for minutes per day (93.8 minutes per day ± 102.3). Non-T1D had the highest values for sedentary activity (237.1 minutes per day ± 176.8).

9.10.3 Table 3: Distribution of PHQ-9 scores according to Depression Status

Level of Depression Severity, PHQ-9 Score	*Total Number Participants (%)*	*Type 1 Diabetics (%)*	*Non-Type 1 Diabetics (%)*
Minimal, 0-4	35 (35.7)	1 (16.7)	34 (37.0)
Mild, 5-9	33 (33.7)	3 (50.0)	30 (32.6)
Moderate, 10-14	17 (17.3)	2 (33.3)	15 (16.3)
Moderately Severe, 15-19	11 (11.2)	0 (0.0)	11 (12.0)
Severe, 20-27	2 (2.0)	0 (0.0)	2 (2.2)

9.10.3.1 Mental Well-being – IPHQ-9 Questionnaire Results

Results from PHQ-9 can be seen in Table 3. Non-T1D reported more severe depression symptoms compared to T1D. Key findings include T1D 33.3% (n=2) showing ‘Moderate’ levels of depression and non-T1D 12.0% (n=11) showing ‘Moderately Severe’ levels of depression.

9.10.4 Table 4: Average Number of Hours of Sleep per night

Average hours of sleep per night	*Total Number of Participants (%)*	*Type 1 Diabetics (%)*	*Non-Type 1 Diabetics (%)*
< 5 hours	3 (3.1)	0 (0.0)	3 (3.3)
5-7 hours	39 (39.8)	2 (33.3)	37 (40.2)
7-9 hours	55 (56.1)	4 (66.7)	51 (55.4)
9 + hours	1 (1.0)	0 (0.0)	1 (1.1)

9.10.4.1 Sleep

Table 4 shows data collected regarding the quality of sleep for participants. The majority of total participants reported 7-9 hours of sleep: total participants 56.1% (n = 55). Key findings include non-Type 1 Diabetics 3.3% (n = 3) reporting < 5 hours of sleep per night and Type 1 Diabetics

66.7% (n = 4) reporting 7-9 hours of sleep per night. A total of 40.8% (n = 40) responses indicated that ‘Going out and socialising’ was the main factor contributing towards the participant’s tiredness, 23.5% (n = 23) for ‘Assignments’, 5.1% (n = 5) for ‘Travelling’ and 14.3% (n = 14) for ‘Attending lectures and seminars’ and 16.3% (n = 16) for ‘Other’.

9.10.5 Table 5 : Diabetes Self-Management Questionnaire (DSMQ) Scores (Type 1 Diabetics only)

DSMQ	***Total Score (n=6)***
Glucose Management	8.7 ± 1.3
Dietary Control	5.7 ± 2.6
Physical Activity	3.0 ± 0.0
Health-Care Use	3.8 ± 1.2
Sum Scale	5.3 ± 0.9

9.10.5.1 DSMQ and PAID Questionnaire Results

Table 5 shows results from the DSMQ (T1D only). Glucose Management scored the highest self-rating and physical activity scored the lowest. Results from PAID reported the highest score among participants was 76.25 which is interpreted as ‘Very high distress’. The lowest score recorded was 11.25 which interprets as ‘Little to no distress’. Out of the 6 T1D participants, 1 scored higher than the recommended value and 5 participants were within the expected range. The mean and standard deviation scores of T1D participants (31.0 ± 21.9).

9.10.6 Nutrition

66.3% (n=65) of non-T1D participants reported that their diet mainly consisted of ‘Carbohydrates’, 29.6% (n=29) of ‘Proteins’, 3.1% (n=3) for ‘Fats’ and 1.0% (n=1) for ‘Vitamins and Minerals’. 66.7% (n = 6) of T1D had a diet mainly consisting of ‘Carbohydrates’ and the remaining 33.3% (n = 2) of ‘Proteins’. Additionally, 17% of total (n = 98) participants were not aware of the nutritional values of the foods that they typically consumed.

9.11 DISCUSSION

This study aimed to investigate the impact of university lifestyle on health, well-being, and performance; to determine any differences between PA levels; disparities and severities of depressive symptoms; sleep patterns and finally nutritional behaviours between university athletes with and without underlying health conditions, with a specific focal point on T1D.

A trend in results was shown in T1D university athletes who reported high moderate-vigorous PA levels in minutes per day (90.0 ± 138.6 and 95.0 ± 74.3) (Table 2). Despite the small sample size of this subgroup, T1D consistently reported a lower depression status (Table 3); this may correlate with increased PA levels (Table 2) and the 66.7% statistic demarcating higher conformity to recommended sleep patterns (Table 4). Additionally, non-T1D university athletes reported a large prevalence of walking-sedentary behaviours (92.5 ± 102.9 and 235.1 ± 174.8) (Table 2), which could suggest a relationship with 14.2% reporting moderately severe-severe depression symptoms (Table 3).

9.12 PHYSICAL ACTIVITY

T1Ds generally reported a higher frequency and duration of MPA and VPA (Table 2). A study looking at young athletes with T1D reports that 60 minutes or more of MPA to VPA is advised to aid mental and physical health considering the vulnerability of living with this condition (50,116). Following this, current guidelines for PA remain consistent between the adult population with and without underlying health conditions. Research from Iafusco et al (50) reports that regular PA is a major, beneficial factor towards good T1D management. Therefore, the need for MPA and VPA is expected for T1D participants within this questionnaire. Of the total of 98 university athletes comprising this study, 6 of the participants were T1D. The small group of T1D who have increased access to professional guidance have demonstrated that they partake in higher levels of PA, indicative of a better education around this subject. Despite previous research indicating that university students tend to demonstrate a high frequency of physical inactivity, when comparing the T1D university athlete to the non-diabetic from our findings, both report high intensities of exercise.

Previous research did not agree with the findings of this study; however, the small sample size makes it increasingly difficult to form conclusions for the wider population. It is expected that a university athlete population would meet the recommendations for PA but research lacks around this demographic with a larger focus being on university students in general. Research from Clemente et al (117) reports that a substantial percentage of university students do not meet the current guidelines for PA levels and rates of excess body weight and obesity have revealed similar results between university athletes and non-athletes (118,119). The study suggests that university athletes participate in higher intensities of exercise which may be linked to increased rest and recovery times. Such results can provide a potential explanation for the increased time spent in sedentary levels of PA and the neglect of a range of responsibilities regarding living and attending university (120). Additionally, non-diabetic university athletes reported fewer days and hours of activity concerning moderate and vigorous levels of intensity.

The implications associated with not meeting the guidelines for PA among an adult population stress include the increased risk of coronary heart disease and cardiovascular disease. Focusing on a university athlete population, an increasing risk is highlighted for a younger generation forming bad habits associated with health status and therefore, threatening the future generation (121). Attending university is a period that associates itself with instability in lifestyle due to the changes from moving away from home. Longitudinal studies assess the relationship between PA levels and obesity and highlight the consistency of weight gain from young adults onwards (122).

Few studies have focused on the use of IPAQ and monitoring the frequency of PA in university athletes. A study by Dinger et al (123), reported that more than 62% of university students were inactive. The focus was on university students in general, therefore suggesting that academic responsibilities or going out and socialising may be the leading cause for the lower levels of PA. For individuals aged 18 and over, this period is reported to have a high incident rate of depression, contributing to a decline in PA levels and academic performance overall among university students (124). Previous studies have highlighted university students as a vulnerable group that frequently exhibit behaviours impacting overall health as a consequence of increased sitting time, decreased rest time, leaving home and living alone, high-stress exposure, and greater access to insufficient food-related habits (125).

9.13 PHQ-9

There was a high incidence of mild to severe symptoms of depression among students, potentially caused by the significant life changes they experience when attending and living at university (83,124,126,127). According to the depression diagnostic status, the distribution of PHQ-9 scores within this study, portrays 14.2% of non-T1D participants as having moderately severe to severe depressive symptoms.

All T1D university athletes (100%) reported a lower, moderate severity and below, of depression symptoms compared to a total of 85.8% of non-T1D university athletes (Table 3). However, due to the small sample size, it would be inaccurate to assume. However, in the presence of a trend were found among increased numbers of T1D university athletes we could suggest the correlation of these findings to increased PA levels suggested from IPAQ results where consistency is present in previous research and therefore, it can be expected that those who participate in more PA will endure a better quality of life (128). Studies report the importance of PA in mental health among university students and student-athletes, highlighting that those who participate in sports at university will have an overall better quality of life (129). However, a study by Powers et al (130) suggested that university athletes have a higher risk of problems with mental health compared to non-athletic students in general due to the additional responsibilities that come with participating in sports alongside studying.

In the few T1D university athletes who participated in this study, lower levels of depression severity were reported compared to non-T1D participants. From this we could suggest that, despite the pressure of managing their condition, they are increasingly physically active thus facilitating a better quality of life, outweighing other responsibilities, such as managing dietary intake and avoiding hypoglycaemia (57). These findings may generalise a better quality of life among T1D, however, due to the number of responses from this demographic, it is difficult to form a definitive conclusion. Additionally, the self-reporting nature of the questionnaire may encourage self-report bias and therefore an error in measure.

9.14 DSMQ

The DSMQ assesses the self-management behaviours of those suffering with T1D. Issues concerning glucose management were reported as the key problem area for T1D, scoring the highest mean (±SD) value (8.7 ± 1.3) (Table 5). Effective management of glycaemic levels relies significantly on the individual with T1D taking responsibility for their condition (112,131). Those with T1D should ensure they are correctly fuelling their bodies alongside administering appropriate exogenous insulin therapy (131).

Longitudinal studies have explored the implications associated with unstable glucose management and have emphasised the acute and chronic consequences where guidelines have not been met. Experiencing regular fluctuations of hypo- and hyperglycaemia associates itself with the increased development of long-term health complications such as cardiovascular disease and type 2 diabetes

(132,133). A range of interventions have been discovered to avoid these complications: changing the insulin regimen, switching to another type of insulin, and managing dietary intake (133). Although not identified in those with T1D, the effect of tight glucose management in individuals with type 2 diabetes has highlighted the reduction of cardiovascular risks with a variety of contributing factors such as age, gender, and duration of diabetes (133). However, despite the ability to form a conclusion around T1D, several studies report a positive impact on decreasing the onset of chronic consequences with intensive glycaemic control (133,134).

Few studies have utilised the DSMQ among active individuals with T1D. Schmitt et al (113), focused on the value of the questionnaire itself and reported that it was a successful measure for healthcare professionals to gain a better understanding of the causes of hyperglycaemia through the evaluation of a patient's self-management behaviours. It was suggested that the behaviours reported on the DSMQ responses matched the HbA1c values recorded, overall, explaining 21 – 28% of glycaemic variation from the results supporting the validity and reliability of this questionnaire (113). Schmitt et al (131), suggested that the questionnaire has good reliability and validity. On the other hand, it is worth noting that the questionnaire uses two-sided questioning (both positive and negative keyed items) and is self-reported: this may 'lower internal consistency' and thus reduce accuracy. Summarising the findings concerning previous literature reporting on the questionnaire, data collected may be valid and reliable, however, the nature of self-reported data collection tends to be biased and responses may be inaccurate.

9.15 PAID SCALE

Results from this study suggest that T1D university athletes experience little to no levels of distress when it comes to managing their diabetes. Poor mental well-being is commonly reported among T1D, influencing glycaemic control which supports the DSMQ findings and may explain the problems areas around glucose management (115). There is a clear distinction between 'general stress' and 'diabetes-related distress'. Patients need to identify and understand this distinction to gain good diabetes control (115). Previous studies found that stress specific to diabetes, which had been measured using PAID, was strongly associated with current depression severity and psychological distress (115). The same study recorded that those with T1D, compared to those with type 2 diabetes, showed more concerns and complications related to hypoglycaemic reactions and management (115). Living with a chronic condition such as T1D can also encourage stress related to both short-term and long-term effects associated with the level of control one has regarding management (135). This could support this study's results through the suggested higher incidence of DSMQ values (8.7 ± 1.3) around glucose management.

9.16 NUTRITION

Most participants reported consuming carbohydrates as their main fuel source and only 18% of non-T1D participants were not aware of the nutritional information within the foods they typically consumed. Regarding T1Ds, 100% indicated that they were aware of the nutritional values. These findings support previous research demonstrating that university athletes should focus on fuelling themselves with adequate macronutrients to aid their performance and avoid fatigue and injury (136). The same study reported 85.6% of university athletes were aware of the basic nutritional knowledge surrounding their lifestyle as well as the concept of a balanced diet (136). This suggests that university athletes may be aware of recommended nutritional behaviours and in fact, may indicate a potential neglect for their health and well-being rather than not knowing how to fuel themselves sufficiently when regularly participating in PA.

9.17 Sleep

As aforementioned, research and healthcare professionals suggest that a student should receive between 7 and 9 hours of sleep every night; significantly, other studies report that < 8 hours of sleep is insufficient and will cause consequences for students concerning their academic and non-academic duties (98,137). Adequate sleep was recorded for 55.4% of non-T1D participants and 66.7% of T1D participants (Table 4). Inadequate sleep was reportedly more prevalent in non-T1Ds (43.5%) compared to T1Ds (33.3%) (Table 4). Research from Rebello et al (98), showed that 'sleep quantity, quality, and behaviours were suboptimal for many university athletes'(138) and that sleep behaviours were consistent across demographic factors such as gender, academic year, and place of residence (98). The majority of athletes reported training/competition to consistently occur later in the evening, inducing increased wakefulness and a later bedtime (97,98). While this may explain our findings about university athletes receiving inadequate sleep, future research may benefit from investigating reasons for the disruption in sleep patterns among university lifestyles. 66.7% of T1D athletes reported an adequate duration of sleep. Research from Perez et al (139), highlights that healthcare professionals have identified sleep as an important consideration among T1D patients due to the relationship it acquires with glycaemic control. The consequences of sleep behaviour for T1D, specifically the correlation between inadequate sleep and insulin resistance, and impaired glucose metabolism are widely researched (15).

9.18 LIMITATIONS

This study has several limitations which may impact the interpretations of the findings. The nature of this data was self-reported and therefore, the honesty of completion, the general understanding of the questions and the field of research was a dependent factor when concerning the individual participants. Under-reporting of symptoms, overscoring on questions, and/or denial issues are the sole reasons for inaccuracy when collecting data from a self-reported survey and is evident across the majority of survey methodology (140). Many participants failed to complete the survey and the reasoning for this is either unclear or unknown. As a consequence of this action, the results may be biased or unrepresentative of the population.

The sample sizes for total participants as well as the number of T1Ds who took part was a significant limitation and may have encouraged untrue results to the wider population. The main issue concerning the sample size within a study is the interpretation of results. Thus, results remain unclear, and conclusions cannot be drawn, instead, it is possible only to comment on trends due to the lack of data supporting research.

9.19 FUTURE RESEARCH

Future research should consider methods of recruiting greater numbers of T1D university athletes, contributing to an increase in the accuracy of results and create more evidence-based assumptions on the topic at hand. In terms of the research itself, future studies could explore detailed factors concerning the transition period for university students and evaluate the effectiveness of student support services in place to lessen the potential negative impacts on university lifestyle. This research could further highlight the demographic group in question as inherently vulnerable regarding their quality of life. A potential increase in attention on university students could result in better student support when embarking on their studies to avoid worsening their overall health status.

9.20 Conclusion

In conclusion, results suggest that a high percentage of university athletes do not meet recommended guidelines within physical and mental health testing. However, when separating total participants into T1Ds and non-T1Ds, T1Ds reported evidence that they conformed to guidelines more so than non-T1Ds. Due to the small sample size within this study, the hypothesis can not be accepted as there is insufficient evidence to create a conclusion for the T1D university athlete population. Both groups recorded PA levels above the recommended guidelines for their age group but differed noticeably when comparing T1D and non-T1D university athletes with T1D university athletes recording a higher prevalence of MPA and VPA minutes per day. While both groups also recorded low severity of depression symptoms, this differed for non-T1Ds where 14.2% of participants reported high severities compared to 0% from T1Ds. From this study, the sample size is a significant limitation when determining the accuracy of results. Conclusions are therefore inconclusive and are restricted to making assumptions based on trends from the data reported.

3

Adipose indices and metabolic health parameters of university athletes with and without Type 1 diabetes

10 ADIPOSE INDICES AND METABOLIC HEALTH PARAMETERS OF UNIVERSITY ATHLETES WITH AND WITHOUT TYPE 1 DIABETES

10.1 ABSTRACT

Purpose: This study assessed and compared the adipose indices, cardio-metabolic measures, and physical activity levels of university athletes with and without T1D. Relationships between T1D and non-T1D university athletes were investigated to determine whether measures consisting of body composition, blood lipid profile, and physical activity levels differed. **Method:** In a cross-sectional design, 22 university athletes: 9 females (1.7 ± 0.09 m;73.4 ± 10.8 kg; 25.0 ± 2.0 kg/m2) and 13 males (1.8 ± 0.07 m; 82.6 ± 12.8 kg; 26.2 ± 3.9 kg/m2) who regularly participated in PA and were a member of a sports team at the University of Essex, completed a series of physiological and metabolic health assessments including HbA1c, blood lipid profile, and a whole-body DEXA scan. Participants were also administered the International Physical Activity Questionnaire (IPAQ) questionnaire to record PA levels. **Results:** Results showed a significant difference in HbA1c and BG between T1D and non-T1D university athletes ($p = < 0.05$). Noteworthy findings included non-significant trends for T1D recording a higher TC, LDL, TRGLY and a lower HDL versus non-T1D university athletes. No significant differences were reported in remaining adipose parameters. IPAQ scores revealed potential findings of increased VPA and MPA levels in T1D university athletes. **Conclusion:** A significant difference in HbA1c and BG was highlighted between groups. Risk factors associated with chronic health consequences may threaten the university athlete population, potentially highlighting the vulnerability of this group and the danger of developing negative behaviours for future health status.

Keywords: HbA1c, blood glucose, DEXA, International Physical Activity Questionnaire (IPAQ)

10.2 INTRODUCTION

Body composition (BC) assessment is of interest to sporting professionals due to its relationship with performance and health (141,142). BC refers to the distribution of lean and adipose tissues as well as the structural, fundamental elements of the human body (143,144). When assessing an athlete’s BC, whether it is at an amateur and/or elite level, it is important to consider factors such as age and gender due to the physiological and hormonal differences among these demographic groups (145). Many athletes are determined to modify BC to achieve optimal performance within their specific sport, however, they may fail to focus on a positive energy balance with good nutritional behaviours (146).

Individuals who participate in regular PA at university, represent a group defined as university athletes that are growing in ‘interest and importance’ (147). The importance of BC in university athletes stems from its profound impact on aspects of performance, health, and well-being. Optimising the balance between muscle and fat mass requires appropriate dietary intake alongside sport-specific training programmes (141,148). University athletes regularly participate in training sessions for their physical conditioning and skill development but are typically not often provided with nutritional advice (148).

Achieving optimal BC can be challenging for individuals with Type 1 Diabetes (T1D) who partake in regular PA. T1D is a chronic condition, characterised by an insulin deficiency due to destructive pancreatic beta cells (149). Effectively managing BC optimises metabolic health and, alongside appropriate PA levels and a balanced diet, will minimise complications associated with the autoimmune disease (149). Balancing lean and fat mass plays a major role in insulin management due to insulin being associated with both glucose and lipid metabolism (150). Good insulin management promotes the growth and maintenance of lean muscle mass (151). It is common for type 1 diabetics to not give themselves enough insulin concerning their dietary intake due to miscalculation of insulin-carb ratios (152). In some cases, these individuals will simply not administer any insulin which is extremely dangerous for the long-term consequences of the condition through the persistence of hyperglycaemia. The lack of insulin will cause weight loss and encourage muscle breakdown, hindering athletic performance and promoting the onset of injuries and poor health (152). Conversely, a common side effect of insulin therapy is weight gain (153).

There are various ways to measure BC. Despite advances in technology, the use of anthropometric measures are the most frequently used variables due to their low cost and simplicity (154). Measures include Body Mass Index (BMI) and Waist Circumference (WC) (1).

10.2.1 Table 6: Classification of Obesity by BMI and WC, relating to the risk of Disease (1).

			Disease Risk* Relative to Normal Weight and Waist Circumference	
	BMI (kg/m^2)	Obesity Class	Men 102 cm (40 in.) Women 88 (35 in.)	Men >102 cm (>40 in.) Women >88 cm (>35 in.)
Underweight	< 18.5			
Normal+	18.5 - 24.9			
Overweight	25.0 - 29.9		Increases	High
Obesity	30.0 - 34.9	I	High	Very High
	35.0 - 39.9	II	Very High	Very High
Extreme Obesity	40	III	Extremely High	Extremely High

***Diseases such as cardiovascular disease, dyslipidaemia, and coronary heart disease**

Table 6 presents the guidelines for BMI and WC as well as the associated risk of disease. These field measures are highly important when identifying whether a patient is overweight, contributing towards the risk of morbidity from coronary heart disease, type 2 diabetes, stroke, cardiovascular disease, and dyslipidaemia (1).

Other methods to measure BC come from advances in technology. High-tech imaging options such as Computed Tomography (CT), Dual-Energy X-Ray Absorptiometry (DEXA), and Magnetic Resonance Imaging (MRI) are methods that offer accuracy and reproducibility (143). Contrasting the use of field and lab measures, the use of lab equipment may be more accurate for researchers but cost, technical complexity, and the lack of portability, make it harder compared to collecting data from field measures (154). However, the use of DEXA is a convenient tool that allows calculations of both regional and total BC, dividing fat and fat-free mass into two components known as lean tissue and bone mineral content (BMC) (141,155,156). For athletes, a DEXA scan provides a large range of body composition data, that can be used to monitor training regime effectiveness and help prepare for competition (141). Its precision, accuracy and speed make this ideal for athletes due to quick analysis, only taking approximately seven minutes to complete one scan (141,156).

10.3 Dual-energy X-ray absorptiometry

Bone density scanning, sometimes referred to as bone densitometry or dual-energy X-ray absorptiometry (DEXA) screening, is a medical method used to assess the strength and mineral content of bones as well as provide an accurate representation of an individual’s BC (157). A DEXA scan involves passing a small quantity of X-ray energy into the bones to assess how much of it is absorbed by them (158,159). Depending on the findings, lifestyle modifications, food and nutrition modifications and exercise recommendations may be given (160). Previous literature has assessed the validity of DEXA and concluded the method produces reliable results, provided there is an applied setting (161). It is highlighted that DEXA is reliable when measuring 'true' BC data but is dependent of the preceding 24 hours regarding food and drink consumption as well as energy expenditure (161).

Visceral adipose tissue (VAT) is defined as the fat mass around the abdominal viscera that is composed of adipocytes (162). Research from Charland et al (163) proposes that a high prevalence of VAT is a predominant cause of metabolic syndrome in both men and women, contributing towards a risk in the development of type 2 diabetes and cardiovascular disease (164). The amount of VAT an individual holds is dependent on 'sex, age, race, ethnicity, genotype, diet, PA, hormone levels and medication' (162,165).

10.4 BLOOD LIPID PROFILE

Blood lipid profile (BLP) is a key measure of metabolic health, made up of total cholesterol (TC), high-density lipoproteins (HDL), low-density lipoproteins (LDL), and triglycerides (TRGLY) (166–168). Research concerning BLP and lipid metabolism has become of interest to healthcare professionals due to the correlation between dyslipidaemia and the development of cardiovascular disease and coronary heart disease (169,170). According to the Third Report of the National Cholesterol Education Program Expert Panel (171), the desirable levels of blood lipids were classified in the form of milligrams per decilitre (mg/dL) and have been converted to millimoles per litre for consistency within this study. TC concentrations have been divided into 3 categories:

‘desirable’ (<5.2 mmol/L),‘borderline’ (5.2 – 6.2 mmol/L), and high (> 6.2 mmol/L) (171). Recommendations for HDL concentrations define as ‘low’ (<1.0 mmol/L), ‘desirable’ (1.0 – 1.5 mmol/L), and ‘optimal’ (> 1.5 mmol/L) (171). LDL levels were classified as ‘optimal’ (<2.6 mmol/L), ‘desirable’ (2.6 – 3.3 mmol/L), ‘borderline’ (3.3–4.1 mmol/L) and ‘high’ (4.1–4.9 mmol/L) (171). Evaluation into the variation of BLP among male and female groups reported higher HDL in women and higher LDL and TRGLY in male, highlighting an increased prevalence of cardiovascular disease in males (172).

Blood lipid profiles are influenced by several factors including sex, race, diet, alcohol intake, and PA levels (169,173). PA has been well-researched in terms of its positive effect on BLP (169). Participating in regular PA and following a balanced diet has demonstrated a positive impact on the elevation of HDL and reduction of LDL (174). Increased PA levels and loss of body fat may influence the improvement of BLP, highlighting the importance of BC for health status and achieving peak performance within an athlete’s sport (175). Research that focuses on the relationship between BLP and university athletes, is lacking, however, as key concepts contributing towards the management of TC, nutritional knowledge, and PA levels in this subgroup are well documented (95,175). The demands university athletes may face regarding training and competition require an appropriate diet that caters to sport-specific needs (95). Three main food groups that are emphasised to provide a sufficient energy balance and good management of BLP are carbohydrates, proteins, and fats (176). These major macronutrients are emphasised for those who are regularly active due to the increased energy, growth, and repair impacts they have on the body (177). For typical training diets, a high carbohydrate intake is recommended and if followed, guidelines state that an athlete’s diet should be 50-55% carbohydrates (177,178). Proteins are vital, supplying essential amino acids for the growth and repair of muscles. The daily requirement of protein is 50-65g depending on gender and body mass, estimated to contribute towards 10-15% of the body's total energy (177). Fats make up approximately 10-15% of body weight and are important when concerning the storage of energy within VAT. Fats hold a high concentration of energy and it yields 9kcal/g compared to the value of 4kcal/g from carbohydrates and proteins (177). Strength athletes compared to endurance athletes will consume different diets, involving increasing certain macro and micronutrients to match their energy expenditure, therefore, athletes must monitor their dietary intake to fit the needs of their sport but be mindful of health status, especially when eating foods high in fat that may result in elevating their TC (179). However, a 'nutrient-dense diet' may not be emphasised enough to university athletes, suggesting that basic nutritional behaviours are not taught, encouraging the lack of understanding and knowledge (95).

Balancing nutritional needs alongside increased energy expenditure may be a challenge for university athletes due to a lack in nutritional knowledge, limited access to appropriate food options, financial difficulties, and working under time constraints related to academic and athletic responsibilities (95,180,181). Expanding on this, increased PA may also increase calorie intake (181). High calories are readily sourced from processed foods, negatively impacting BLP. However, they are highly convenient for a student as it is time effective and require little effort (182). These aspects can easily encourage unhealthy habits that will lead to complications concerning metabolic health measures and achieving peak performance (95,181,182).

10.5 HbA1c

HbA1c is a metabolic measure that reflects an individual’s average blood glucose concentration over the course of 3 months (183). It is a useful measure to monitor overall health status and potentially predict the onset of diabetes. Research from McEwan et al (184), states that an HbA1c > 48 mmol/mol (6.5%) is associated with the diagnosis of diabetes. A high HbA1c usually occurs through lack of insulin and/or potential insulin resistance and means blood glucose levels are in a hyperglycaemic state where an individual will be exposed to unstable blood glucose management (183). A low HbA1c will indicate a lack of glucose in the bloodstream (183,185).

Glucose is heavily sourced from consuming carbohydrates which are the body’s main energy source (178). Lacking carbohydrates may result in fatigue which encourages the onset of injury, a decline in mental well-being, and is detrimental to performance. Additionally, another factor that causes fluctuations in blood glucose levels is stress (186). Stress is detrimental to HbA1c levels. Because university athletes have been identified as being overwhelmed by transitioning away from habitual supervision as well as juggling studying and athletic expectations, monitoring and management of stress should be considered (186).

For T1D individuals, HbA1c is a key measure providing a general, longer-term overview of their blood glucose management. It allows healthcare professionals to gain an understanding of a patient’s problem areas and ensure that they are healthy and managing their condition adequately. According to the National Institute for Health and Care Excellence (NICE), T1Ds should achieve a HbA1c of <59 mmol/mol (7.5%) (184). Research from McEwan et al (184), reports that 71% of those with T1D failed to achieve this and more recently, guidelines have been reviewed by NICE and the target has changed to 48 mmol/mol (6.5%). For a T1D athlete, targets will be set to achieve a good HbA1c consisting of regular PA, with its explored benefits of increased life expectancy, improved psychological benefits, and reductions in diabetes-related conditions such as neuropathy, retinopathy, and nephropathy (187).

10.6 Aims and Objectives

When comparing the adipose indices and metabolic measures of T1D and non-diabetic university athletes, challenges, and barriers towards living both a physically and mentally healthy lifestyle remain consistent. However, for a T1D, extra pressures are introduced regarding diabetes management and ensuring they are prioritising their health over other responsibilities. Attending university highlights overwhelming changes to an individual's routine and this study investigates whether T1D university athletes differ to non-diabetics in terms of body composition and overall health status whilst experiencing a university lifestyle. The study aim is to assess and compare the adipose indices, cardio-metabolic measures, and physical activity levels of university athletes with and without T1D.

The null hypothesis is that there will be no significant difference in BC or lipid profile measures between T1D and non-diabetic athletes, despite, likely differences in BG.

10.7 Method

10.7.1 Study Design

In a cross-sectional design, participants were assessed for anthropometric, metabolic and body composition measures under standardised conditions. All testing procedures were conducted over a two-month period. The study was approved by the University of Ethics Committee Sub-Committee 2 (ETH2223-0905).

10.7.2 Participants

University athletes aged 18-24 years old, who regularly participated in PA and were a member of a sports team, with or without T1D were invited to participate in the study through social media platforms. 22 university athletes: 9 females (1.7 ± 0.09 m) (73.4 ± 10.8 kg) (25.0 ± 2.0 kg/m^2) and 13 males (1.8 ± 0.07 m) (82.6 ± 12.8 kg) (26.2 ± 3.9 kg/m^2) volunteered to participate in the study.

10.7.3 Anthropometric Measures

Participant height was determined using (Seca 213 stadiometer, Hamburg Germany). Individuals were asked to remove their shoes and stand with their back to the equipment. Participants were told to take in a deep breath and the measurement was taken in-line with the top of their head. Body mass was measured with participants wearing minimal clothing (Seca 813 Electronic flat scales, Hamburg Germany). Individuals were asked to step onto the scales where the measurement was taken from the digital screen. BMI was calculated from height and body mass measures (kg/m^2).

10.7.4 Body composition

One whole-body dual energy x-ray absorptiometry (DEXA) scan was completed for each participant using a pencil beam DEXA scanner (Hologic Discovery W, Marlborough, MA) with analysis performed using APEX 2.3.1 software (Hologic). Participants were positioned supine along the mid-line of the DEXA table, arms by their side and palms facing down, with the legs shoulder width apart and internally rotated, and the feet taped together at the metatarsophalangeal joint to maintain a fixed position throughout the duration of the scan. The DEXA scanner was stable on daily phantom quality assessment and calibrated daily. Analysis of the whole-body scans were used to quantify whole body fat mass (kg) and visceral fat mass (g) for the purpose of this study. The same technician performed and analysed all DEXA scans.

10.7.5 Blood lipid profile and HbA1c

Blood lipid profile was assessed via a sample of (40μL) capillary blood extracted from the fingertip and analysed using a Cholestech LDX™ analyser (Cholestech LDX™, Chicago, Illinois, United States). The Profile-GLU cassette measured total cholesterol (TC; mmol/L), high density lipoprotein (HDL; mmol/mol) cholesterol triglycerides (TRGLY mmol/L) and blood glucose (GLU; mmol/L).

10.7.6 International Physical Activity Questionnaire

The use of questionnaires is an efficient method to collect data from a study. For this study, PA levels is a contributing factor towards the adiposes indices and metabolic measures that are favoured to establish potential differences in T1D and non-T1D university athletes. A validated method that has been well-documented to measure PA levels in the population is the International Physical Activity Questionnaire (IPAQ). IPAQ is a tailored survey, created for adults (18-65 years old), that has been approved in 12 countries (111,188). The IPAQ includes a set of four questions that investigate the intensity of exercise and the total duration that each participant spends within those intensities. The IPAQ has four subsections regarding intensity and duration of exercise in a typical week: vigorous, moderate, walking, and sedentary. The purpose of the questionnaire is to provide subjective responses towards everyday life that can be used to obtain internationally comparable data on health–related PA (111). The number of days per week and the amount of time per day spent engaging in vigorous and moderate exercise are tracked for each of the four areas. Walking time is also accounted for during work, travel, and free time (111). These subsections are measured in hours and minutes. Questionnaires were self-reporting and may pose errors in measures when analysing results.

10.7.7 Statistical Analysis

Data were analysed using IBM Statistics SPSS 29 (Armonk, New York). Descriptive statistics were used to depict population data and was divided into T1D and non-T1D university athletes. The mean (±SD) values for the dependant variables for BC, BLP and IPAQ were calculated for T1D and non-T1D university athletes. The Shapiro-Wilk test was used to assess the normality distribution for each dependent variable. In cases where the normality distribution was violated, a non-parametric approach was used.

Independent t-tests were used to determine if there were any differences between the parameters of T1D and non-T1D university athletes where data was normally distributed. In cases where data was non-normally distributed a Mann-Whitney U test was used. Associations between the test groups and physiological measures were determined using independent t-tests to test the level of significance. Data were reported as mean (± SD) values and statistical significance was set at $p<0.05$.

10.8 RESULTS

Descriptive statistics for T1D (n=4) and non-T1D (n=18) university athletes are shown in Table 6.

10.8.1 Table 7: Descriptive Statistics of Body Composition Measures among T1D and Non-T1D University Athletes (mean ± SD)

		T1D Participants (n=4) (mean ± SD)	*Non-T1D Participants (n=18) (mean ± SD)*
Body Composition	Height (m)	1.8 ±1.0	1.7 ± 0.8
	Weight (kg)	84.0 ± 24.2	77.8 ± 10.1
	BMI (kg/m^2)	26.4 ± 4.9	25.5 ± 2.8
	WC (cm)	93.0 ± 13.2	88.8 ± 7.5
	Body Fat (%)	28.8 ± 8.5	30.3 ± 6.7
	FMHS (kg/m^2)	7.6 ± 2.7	7.7 ±2.3
	Fat Mass (kg)	25.2 ± 9.1	22.8 ± 5.8
	Total Visceral Body Fat (kg)	0.8 ± 0.5	0.7 ± 0.3

BMI = Body mass index, WC = Waist circumference, FMHS = Fat Mass Height Squared

10.8.1.1 Body Composition

No significant difference ($p = > 0.05$) was found among BC parameters between T1D and non-T1D university athletes. Key findings related to being categorised as overweight and at risk of chronic disease: T1D university athletes BMI (26.4 ± 4.9 kg/m^2) and non-T1D participants BMI (25.5 ± 2.8 kg/m^2). T1D university athletes WC (93.0 ± 13.2 cm) and non-T1D participants (88.8 ± 7.5 cm). Body fat percentage was higher in non-T1D participants (30.3 ± 6.7 %). Fat mass was higher in T1D participants (25.2 ± 9.1 kg).

An independent t-test was conducted to compare the mean results of the adipose indices between T1D participants and non-T1D participants. A significant difference was found in T1D and non-T1D university athletes for Weight ($t = -0.90$, $p = 0.02$). No significant differences in BC were observed between T1D and non-T1D university athletes. BMI ($t = -0.437$, $p = 0.14$), Height ($t = -0.778$, $p = 0.44$), Height Squared ($t = -1.08$, $p = 0.33$), Body fat % ($t = 0.39$, $p = 0.44$), FMHS ($t = 0.06$, $p = 0.41$), Fat mass: ($t = -0.68$, $p = 0.19$) and Total Visceral body fat: ($t = -0.38$, $p = 0.27$).

10.8.2 Table 8: Blood Lipid Profiles and Blood Glucose Measures for Type 1 Diabetic and non-Type 1 Diabetic University Athletes

	Total Participants (n=22) (mean ± SD)	*T1D Participants (n=4) (mean ± SD)*	*Non-Type 1 Diabetic Participants (n=18) (mean ± SD)*
TC (mmol/L)	3.7 ± 0.6	3.9 ± 0.4	3.7 ± 0.6
HDL (mmol/L)	1.3 ± 0.4	1.2 ± 0.6	1.4 ± 0.3
LDL (mmol/L)	1.9 ± 0.5	2.2 ± 0.5	1.9 ± 0.4
TRGLY (mmol/L)	0.9 ± 0.3	1.1 ± 0.4	0.9 ± 0.3
BG (mmol/L)	5.3 ± 1.3	7.2 ± 1.8	4.9 ± 0.4
HbA1c (mmol/mol)	34.4 ± 14.1	55.0 ± 23.7	29.8 ± 1.3

TC= Total cholesterol, HDL= High-density lipoproteins, LDL= Low-density lipoproteins, TRGLY = Triglycerides, BG = Blood glucose

10.8.2.1 HbA1c and Blood Glucose

A significant difference was found in HbA1c between T1D and non-T1D university athletes ($p=<0.05$). Key findings reported T1D participants having a high mean HbA1c (55.0 ± 23.7 mmol/mol) compared to non-T1D participants (29.8 ± 14.0 mmol/mol).

A significant difference was found between T1D and non-T1D university athletes in BG ($t = -4.70$, $p = 0.00$).

10.8.2.2 Blood Lipid Profile

Table X reported the mean (±SD) for BLP of T1D and non-T1D university athletes. An independent t-test was conducted to compare the mean results of the metabolic measures between T1D participants and non-T1D participants. No significant differences in BC were observed between T1D and non-T1D university athletes. TC ($t = -0.61$, $p = 0.32$), HDL ($t = 0.95$, $p = 0.14$), LDL ($t = -1.17$, $p = 0.24$) and TRGLY ($t = -0.77$, $p = 0.54$). There were non-significant trends for higher TC, LDL and TRGLY, and lower HDL in T1D versus non-T1D athletes.

10.8.3 Table 9: Mean and Standard Deviation of IPAQ Questionnaire Results

		Total Number of Participants (mean ± SD) (n = 22)	*T1D (mean ± SD) (n = 4)*	*Non-T1D (mean ± SD) (n = 18)*
Vigorous Activity	***Days per week***	3.5 ± 1.5	3.8 ± 0.8	3.5 ± 1.6
	Minutes per day	90.7 ± 35.2	112.5 ± 24.9	85.8 ± 35.3
Moderate Activity	***Days per week***	2.8 ± 1.8	3.8 ± 1.3	2.6 ± 1.8
	Minutes per day	64.1 ± 42.2	93.8 ± 52.4	57.5 ± 36.5
Walking	***Days per week***	5.2 ± 1.9	4.3 ± 2.6	5.4 ± 1.7
	Minutes per day	56.8 ± 33.5	45.0 ± 26.0	59.4 ± 34.4
Sedentary	***Minutes per day***	288.6 ± 81.0	357.5 ± 71.5	273.3 ± 74.8

10.8.3.1 IPAQ Questionnaire

No significance difference ($p = > 0.05$) was found in IPAQ scores between T1D and non-T1D university athletes. Mean VPA reported 112.5 minutes per day for T1D participants ($n = 4$) and 85.8 minutes per day for non-T1D participants. Mean MPA reported 93.8 minutes per day for T1D participants ($n = 4$) and 57.5 minutes per day for non-T1D participant.

10.9 DISCUSSION

The aims of this study were to compare the adipose indices and metabolic measures of university athletes with T1D versus those without T1D, alongside self-reported measures of weekly PA. Independent t-tests were conducted with dependent variables between T1D and non-T1D university athletes. A significant difference was found in HbA1c and BG between T1D and non-T1D university athletes ($p < 0.05$).

10.10 HBA1C AND BLOOD GLUCOSE

There was a significant difference in HbA1c and BG between T1D and non-T1D university athletes ($p = <0.05$). Findings from this study showed an elevated HbA1c (55.0 ± 23.7 mmol/mol) and BG (7.2 ± 1.8 mmol/L) in university athletes with T1D compared to participants without (Table 8). A non-T1D population with a normal blood glucose range should achieve an HbA1c of < 37 mmol/mol (5.5%) with an average BG of 6.17 mmol/L (189). A HbA1c level of > 48 mmol/mol with an average BG of 8.57 mmol/L, promotes the diagnosis of diabetes, indicating the higher prevalence of hyperglycaemia (68,184). Therefore, it can be expected to find increased HbA1c and BG levels among a T1D population of university athletes.

The implications of elevated HbA1c and BG levels are strongly associated with chronic health consequences, such as cardiovascular disease, type 2 diabetes, and increased risk of mortality (183,185,190,191). Long-term complications affecting the eyes, kidneys, and nervous system also present a large association with the high prevalence of hyperglycaemia (192). Previous studies reported that 71% of T1D in England and Wales fail to achieve the optimal HbA1c of 48 mmol/L (184) suggesting that PA alone is not protective in this population. The same study states that if the UK population of T1D aimed to reduce their HbA1c by 4 mmol/L, 81,000 microvascular and 7,000 macrovascular events could be avoided, improving diabetes management and reducing the strain on the healthcare sector (184). Previous studies emphasise the consistent association between T1D and increased mortality (56,193).

Longitudinal studies highlight the significant relationship between demographic factors such as age, gender, and race presenting poor HbA1c trajectories (194). Research from Luo et al (194), conducted research into the associations of demographic factors with poor HbA1c trajectories and noted that a higher proportion of T1D compared to those with type 2 diabetes, demonstrated a higher prevalence of instability within their glycaemic control, inevitably contributing to an elevated HbA1c. This study focused on the younger generation, potentially highlighting poor diabetic management that could shape future behaviours, contributing towards a higher risk of the onset of cardiovascular diseases as well as retinopathy and neuropathy (194).

Despite this research on hyperglycaemia, the fear of hypoglycaemia in T1D patients, especially for athletes during exercise, is frequently talked about (6,195,196). Risk factors of hypoglycaemia include warm environments, obesity, exercise and younger age (197). In addition to this, the risk factors for hyperglycaemia consist of high-intensity exercise, psychological stress, dehydration, and errors in insulin/carbohydrate management (197) Compared to a high HbA1c, a low value typically emphasises the short-term risks for T1D and are recognised through symptoms such as sweating, drowsiness, shakiness and confusion (16). The implications of a low HbA1c are well-researched for being less common among patients and its occurrences are strongly associated with highlighting additional underlying health disorders in T1D and non-T1D patients (198). Research from Abdelhafiz et al (198) suggests that a lower HbA1c is more beneficial than a higher value as long as it falls between the recommended range and isn't indicative of additional underlying health issues.

This concern over hypoglycaemia may suggest the neglect of tight glucose management to avoid hyperglycaemia. From this, assumptions can be made that the avoidance of hypoglycaemia is more beneficial for the individual as it doesn't necessarily affect the short-term (197). Research from Balfe et al (199), highlights the lack of research addressing university students with T1D but states that based on existing research, it can be assumed that this period encourages risky behaviour encouraging students to 'go out of control' concerning their dietary intake, sleeping patterns, and attendance of increased social events (200). This indication of risky behaviours may promote the T1D to experience a regular hyperglycaemic state to avoid the complications of dealing with hypoglycaemia within unfamiliar environments (199). Studies indicate that those with T1D live two lifestyles at university, one concerning their diabetes and the other of the university itself and that it is dependent on the attitude of the individual as to which one they prioritise (199).

10.11 Blood Lipid Profiles

There was no significant difference ($p = > 0.05$) found in HDL ($p = 0.14$), LDL ($p= 0.24$) and TRGLY ($p = 0.54$) between T1D and non-T1D university athletes. A potential reason for these findings may be due to the small sample size of T1D university athletes participating in this study. Although not statistically significant, a noteworthy finding was reported in the mean (±SD) values for BLP (Table 8), indicating lower HDL (1.2 ± 0.6 mmol/L) and higher LDL (2.2 ± 0.5 mmol/L) in T1D university athletes, compared to a higher HDL (1.4 ± 0.3 mmol/L) and a lower LDL (1.9 ± 0.4 mmol/L) in non-T1D university athletes. Although the findings demonstrate values within the normal ranges associated with BLP, the T1D university athletes still demonstrate a 0.2 mmol/L difference in HDL and a 0.3 mmol/L difference in LDL compared to non-T1D university athletes (Table 8). Despite the small difference, the tendencies presented in the data suggest that T1D university athletes are on the borderline for a healthy range of these BLP parameters. Norms associated with the desirable ranges of BLP measures for the non-T1D and T1D population are as follows: HDL (>1.4 mmol/L), LDL (<2.2 mmol/L), and TRGLY (<1.0 mmol/L) (201).

It is recommended that the T1D population should have their BLP assessed at least once, annually due to elevated levels of BLP presenting associations with chronic complications, being a primary cause of morbidity and mortality (202). Increased TRGLY and reduced HDL present a strong link with the visceral adiposity index highlighting strong correlations with the risk of cardiovascular disease and type 2 diabetes among T1D patients. Research from Greenfield et al (203) states that cardiovascular disease is a predominant cause of morbidity and mortality in T1D with insulin resistance potentially being a strong predictor of this. Insulin resistance, although more common in non-diabetic and type 2 diabetic patients, contributes towards the increase in visceral adiposity, relating to the increased onset of chronic health consequences (203). T1D presents exogenous insulin therapy as an intervention to manage the condition and control hyperinsulinemia. Hyperinsulinemia is defined as having too much insulin within the bloodstream to be considered as healthy and has been researched as a contributing factor for the T1D population to cause increased abdominal fat (203). Other researched interventions highlight the importance of advising the younger generation with T1D to engage in PA, alongside appropriate insulin therapy and dietary adjustments (204).

Longitudinal studies highlighted that a poor BLP presented itself as a major risk factor for the progression of cardiovascular disease (205). Research from Dayimu et al (205) reports that higher levels of TC, LDL, and TRGLY, alongside a reduction in HDL, are strongly associated with the development of cardiovascular disease. Relating to the findings of this study, concerns may be raised through indications of an unstable BLP within a young generation studying at university. The tendencies found among results suggest T1D university athletes may present a potential risk associated with increased development in the chronic complications regarding suggested lower HDL and higher LDL serum concentrations.

10.12 Body Composition

No significant difference ($p=<0.05$) was found in BMI ($p=0.19$), for T1D and non-T1D university athletes. However, a significant difference ($p=<0.05$) was found in Weight ($p = 0.02$). T1D university athletes' mean weight was 84.0 (± 24.2) kg and non-T1D university athletes 77.8 (± 10.1) kg) (Table 7) presenting a small difference overall. Further evaluation into the mean *(*±SD) values of test groups, although not statistically significant, noteworthy findings from this study were T1D participants exhibiting higher values for BMI between T1D and non-T1D university athletes. According to the current guidelines for BMI, both test groups were classed as overweight (T1D = 26.4 ± 4.9 and non-T1D = 25.5 ± 2.8 kg/m^2) (Table 7). A high BMI forms several concerns for the population where a BMI > 25 kg/m^2 indicates being overweight and > 30 kg/m^2 indicating obesity. Obesity is a primary contributing factor towards cardiovascular disease and an increased mortality rate (206,207). Predominant causes that have been highlighted in research consist of changes in food environment and levels of PA (208).

Following this, no significant difference was shown in Body Fat % ($p = 0.39$) between T1D and non-T1D university athletes. Previous research has shown a strong correlation between body fat percentage and BMI and emphasised a substantial interference by demographic factors such as gender and age (209). Despite being a common method to measure one's overall health and BC, BMI cannot determine the difference between fat and muscle composition. Research from Ilman et al (209) gave the example of a university athlete will have 'solid bone and well-developed muscle' which would increase overall weight and therefore, will result in a higher BMI and could potentially categorise them as being overweight. This could provide explanation towards the findings of this study where BMI was elevated and a significant difference was reported in weight as certain participants could have obtained a lot more muscle than others, reporting an increased body weight.

Previous studies have acknowledged associations between being overweight/obese with a university student through a high prevalence of processed foods, a lack of PA, disrupted sleep patterns, alcohol intake and tobacco use (208). The findings from this study, do not agree with the lack of PA levels due to the nature of the university athlete, however, previous studies highlight a limitation for this research where dietary intake has not been investigated and therefore the elevated BMI measures may be a result of this. Due to the small sample size within the study, a definitive conclusion cannot be formed to suggest the differences in weight contributing towards the BMI of the university athlete population. Future research may benefit from exploring the typical nutritional behaviours of the university athlete as it is expected that they are meeting the guidelines for PA to avoid being overweight/obese.

Similarly to reported BC parameters, excess VAT is associated with chronic health problems and the higher prevalence of obesity, contributing to the increased incidence of cardiovascular disease (210). No significant difference was found in Total Visceral Body Fat ($p = 0.19$)

between T1D and non-T1D university athletes. Further evaluation into the mean (±SD) values in test groups, produced noteworthy findings. T1D university athletes reported a higher Total Visceral Body Fat (0.8 ± 0.5 kg) compared to non-T1D university athletes (0.7 ± 0.3 kg) (Table 6). Interpreting VAT results presents difficulties within literature due to the use of different units, dependent of the method used to measure visceral adiposity i.e using CT, MRI or DEXA (211). Few studies are evident in the relationship between VAT and T1D. Research from Grabia et al (212), analysed a younger group of T1D participants and split groups into those with one or more risk factors of metabolic syndrome consisting of elevated metabolic health measures, one of those being BLP. T1D participants with one or more risk factors scored a higher VAT measure. This study may suggest a level of consistency within the findings from the current study where elevated HbA1c, BG and LDL were suggested higher in T1D, alongside a higher prevalence of VAT. Research relating to T1D university athletes BC is scarce but findings support previous literature concerning general population with T1D. Brazeau reported that >50% of those with T1D were overweight, possibly due to the extensive use of insulin therapy which commonly induces the increase in body mass (153). Previous studies have noted that T1D individuals should be 'normal-weighted' but in the case of a higher prevalence of VAT, it may be linked to insulin resistance, hindering diabetes management (213). The lack of insulin will impair blood glucose management as the nature of insulin is to level and maintain the amount of glucose within the blood. Additionally a lack of insulin will induce weight loss and some may argue that weight gain in T1D should be normalised and it will typically mean that they are administering insulin correctly and the weight gain is more so an issue concerning calorie intake (214). If this would be the case, the findings from this study may provide another example as to why the absence of information regarding dietary intake would be a limitation.

10.13 IPAQ

No significant difference was found among scored subsections between T1D and non-T1D university athletes ($p = > 0.05$). For the purpose of discussion, the mean (± SD) values of IPAQ scores were calculated for the four subsections of the questionnaire: VPA MPA, Walking and Sedentary activity (Table 9). Investigation into PA levels of T1D and non-T1D university athletes, a noteworthy finding was that T1D university athletes performed increased levels of MPA and VPA (112.5 ± 24.9 and 93.8 ± 52.4 minutes per day) compared to non-T1D (85.8 ± 35.3 and 57.5 ± 36.5 minutes per day: Table 9). Current guidelines for adults (18+) are as follows: 150 – 300 minutes of MPA and 75 – 150 minutes of VPA each week or an equivalent combination of both (215). The findings from this study report that VPA exceeds the guidelines with total participants (n = 22) scoring 90.7 (± 35.2 minutes) per day and 3.5 (± 1.5) days per week), which is more than twice the recommended amount. Additionally, findings reported MPA for total participants 64.1 (± 42.2 minutes) per day and 2.8 (± 1.8) days per week.

Despite university athletes with T1D having a trend towards higher activity levels than those without T1D, the BLP in T1D athletes appears worse. This suggests that even though T1D university athletes are engaging in more PA, it may not be sufficient to mitigate negative health effects of having T1D at university. PA in university students has been well-studied as a population presenting unique characteristics (117,216). The physical and mental changes they may endure from entering a new environment with academic and non-academic responsibilities emphasise themselves as influences towards excess body weight and obesity (117). Being an athlete at university promotes increased PA levels and therefore, we would expect the T1D and non-T1D university athletes to meet current guidelines, mainly due to the nature of their lifestyle at university considering training commitments and participation in competition. It is possible that inactivity in university athletes may not be a main cause of the differences in health parameters within this study but, given the small sample size in this study, more research is needed to confirm this.

IPAQ has been researched for its validity and due to its self-reporting format, self-report bias is encouraged. Previous literature has commented on participants having different interpretations of the intensities of PA, causing instability and inaccuracy of results (217,218). Despite the limitations, the questionnaire is cheap, convenient, easy to distribute and covers a range of intensities to investigate PA levels. For future research, previous studies have suggested the use of readily available, shorter versions of the questionnaire, with the use of practical examples to distinguish the intensities, aiming for more accurate representation (217).

10.14 Limitations and Future Directions

This study has several limitations. There was a small sample size of T1D university athletes, which was likely to contribute towards inaccuracy of results and the inability to relate findings to the wider population. If this study was repeated, improved recruitment for those who are physically active with T1D is needed. The validated questionnaire utilised within this study was self-reported, encouraging response bias and inflating and under-reporting (67). The issues related to IPAQ as a self-reporting questionnaire are likely to be predominantly down to participants not understanding the questions and/or providing false information that over or under estimates their PA levels to avoid a negative image on themselves as an athlete (67). Interpretation of results must be completed with caution. Furthermore, there was a lack of emphasis on a university athlete's dietary intake which poses as a key component when analysing BC and metabolic health. Additionally, dietary intake is a key problem area for university students, therefore, inevitably may affect the university athlete and how they lead their lifestyle. Dietary information and carbohydrate intake are also imperative aspects for those with T1D and could have been an indicator the support further findings in this topic of research.

This study was of cross-sectional design. Future studies should consider longitudinal designs to monitor performance and health of T1D university athletes over a longer period and assess the challenges and adaptations they face compared to non-T1D university athletes. Longitudinal studies allow researchers to create a comparison between data and would be beneficial for analysing whether a participant's dietary intake and training programmes are optimising performance and reaching goals. Additionally, this would be beneficial to the T1D community to support athletes at university managing their condition and conducting strategies from data to better performance and aid this demographic by easing and improving diabetes management.

10.15 Conclusion

In conclusion, a significant difference was found in HbA1c and BG between T1D and non-T1D university athletes. Similarities were suggested in T1D and non-T1D university athletes, regarding their body composition, potentially down to the increased PA levels shown across both groups. The small sample size promoted difficulties in forming definitive conclusions across the study, but previous literature demonstrated consistency within the vulnerability of university students concerning their lifestyle choices and knowledge associated around nutritional behaviours. Despite the increased PA levels highlighted in this study, the risk factors associated with chronic diseases may still threaten the university athlete population suggesting the potential need for support to encourage this demographic to avoid shaping future behaviours from poor lifestyle choices at university. In summary, from the significant differences that were found, it can be assumed that there is a lack of concern for the long-term consequences of hyperglycaemia in T1D university athletes, based on the assumption that the fear of hypoglycaemia is prioritised. In turn, this may indicate the lack of support for this group in terms of highlighting the negative impacts associated with the onset of chronic diseases, although this requires further clarification. Furthermore, the study suggests that T1D doesn't necessarily pose as a barrier that effects an university athlete's athletic behaviours and health status, however, it could be suggested that the university lifestyle was more of a threat to the development of poor health behaviours associated with PA and metabolic health, emphasising potential ideas for future research to investigate this vulnerable demographic to assess the knowledge in this industry and the support services in place to shape a healthier future generation.

4

Discussion of Findings and Recommendations for Future Research

11 Thesis Summary

11.1 Summaries, limitations and further research

11.1.1 Summary

This thesis aimed to investigate the physical and mental health of T1D university athletes. The literature review focused on exploring the nature and diagnosis of T1D as well as being an athlete with the condition, reporting on key aspects relating to being at university and managing the condition away from habitual supervision. The first experimental study investigated the PA levels, nutritional behaviours, mental well-being, and sleep quality in university athletes and how they were impacted by university lifestyles. The second experimental study explored BC utilising adipose indices and investigated metabolic measures and questionnaire-based measures targeting PA, comparing T1D and non-T1D university athletes.

The literature review focused on T1D and outlined key aspects of being an athlete at university and what may affect this group as well as university athletes in general. Conclusions from the study's findings suggested that university lifestyle had a big impact on T1D and non-T1D university athletes due to academic and social expectations, alongside training/competition. T1D athletes were suggested to have greater complexities managing their condition on top of these expectations, however, for both groups, it was outlined that with the right support and knowledge, positive outcomes were inevitable.

A descriptive study was conducted utilising four validated questionnaires: IPAQ, PHQ-9, DSMQ and PAID Scale. Additional questions assessed factors related to PA, nutrition, mental well-being, and sleep. 98 university athletes were recruited. Participants were divided into those with and without T1D. The first experimental study found that a high percentage of university athletes did not meet the recommended guidelines for physical and mental health testing. When assessing both groups, T1D participants performed increased MPA and VPA suggesting a better quality of life, with glucose management being highlighted as the largest problem area.

In an experimental study, 22 university athletes with and without T1D completed physiological testing, utilising one validated questionnaire: IPAQ. Physiological testing included one whole-body DEXA scan, blood lipid profile and HbA1c. Physiological measures of BC presented no significant difference between T1D and non-T1D university athletes, along with selected metabolic health measures taken from BLP: TC, HDL LDL and TRGLY. A significant difference was found in HbA1c and BG between these test groups where T1D university athletes reported elevated measures of both variables.

11.1.2 Discussion

Across this thesis, it is suggested that a large proportion of the university athlete population does not meet the guidelines for physical and mental health testing suggesting a high prevalence for physical inactivity and poor mental health within this demographic. There is a danger for this group to shape negative behaviours being away from habitual supervision, impacting future development and potentially increasing the onset of chronic health complications.

11.1.2.1 Transition from Home to University

The transition period from home to university is one that is categorised as overwhelming. Attending university brings on routine changes to an individual's lifestyle concerning factors such as their PA levels, dietary intake, sleeping patterns and mental well-being. It is important to emphasise the vulnerability of the university student population and explore the acute and chronic health implications that may occur as a result of adopting a new lifestyle away from home among a new environment (3). A high prevalence of sedentary behaviour is assumed within this population due to a university student's routine of attending lectures and prolonged durations of sleep. Being an athlete at university associates itself with the athletic and academic responsibilities, potentially increasing the risk of developing both physical and mental health problems.

11.1.2.2 The University Athlete

The nature of a university athlete provides the expectations that this population should be physically active. This expectation creates the assumption that university athletes may be somewhat protected against poor habits developed at university associated with poor nutrition, sleep deprivation and a bad mental well-being. Poor health behaviours may still be evident and will shape future habits of this population, increasing the risk of elevating the onset of long-term health consequences. From the findings within this study, the high prevalence of the university athlete population not meeting the PA guidelines and the reporting of negative mental health symptoms may suggest the lack of education and support in these areas. Improving support systems delivering knowledge and aid to those who are vulnerable, may induce a positive impact on the overall health status of the university athlete population.

11.1.2.3 The Type 1 Diabetic University Athlete

Relating to findings within the non-T1D university athlete population, T1D university athletes suggested higher MPA and VPA levels. This could suggest that their access to healthcare professionals, provides them with a better education around the benefits of PA regarding current recommendations (3). T1D university athletes suggested a better quality of life compared to non-T1D university athletes, assuming because they engaged in higher amounts of PA. Conforming to a healthy active lifestyle is highly advised to T1D to support their diabetes management and to avoid diabetes-related complications such as retinopathy, neuropathy, and nephropathy. No significant difference was reported in BC parameters in T1D and non-T1D university athletes but a higher prevalence for elevated BMI and VAT was suggested in those with T1D.

11.1.2.4 Differences in HbA1c and Blood Glucose

A significant difference was reported in HbA1c and BG values between T1D and non-T1D university athletes. A key problem reported in findings among T1D participants was glucose management. Due to the consistent association between T1D and increased mortality, elevated metabolic health measures pose as an extreme concern for this population. Lack of research is evident around T1D university athletes, however due to the nature of this title and the findings from this study, it can be assumed that PA levels are not an indicator of the significant difference found concerning HbA1c and BG. The cardiometabolic health of the T1D population is important to not only support the management of their condition but to lessen the risk of the development of chronic complications such as cardiovascular disease and type 2 diabetes. To achieve optimal glycaemic control, an individual with T1D should focus on following a healthy active lifestyle, meeting the PA guidelines as well as conforming to a balanced diet, contributing towards a positive impact on metabolic measures such as BLP and HbA1c.

11.1.2.5 Hypoglycaemia and Hyperglycaemia

It is well-documented that the fear of hypoglycaemia is evident among T1D, suggesting that a lack of concern is associated with hyperglycaemia. Fluctuations in blood glucose are inevitable for a T1D athlete due to the body utilising glucose as an energy source during PA, meaning the T1D has to adapt insulin dosages and ensure they fuel themselves efficiently with appropriate amounts of macronutrients to achieve a good performance. Slight miscalculations in insulin dosages or insulin-to-carb ratios, mean the more likely a T1D will experience hypo- and hyperglycaemia, negatively impacting pre-, during, post and even several hours after activity. Regular high blood glucose levels are highly detrimental to an individual's health and will promote the onset of cardiovascular diseases. Experiencing these difficulties at university presents itself as an increasing concern due to the period of time being crucial for future development of long-term habits.

11.1.2.6 Comparing Type 1 Diabetic and Non-diabetic University Athletes

The thesis aimed to assess whether the impact of university lifestyles differed between a T1D and non-T1D university population, additionally comparing the adipose parameters and metabolic measures, investigating whether these differed between the same groups. The research highlighted that despite the associations with increased mortality of a T1D patient, a non-diabetic population should still acquire the same knowledge regarding the risk factors that promote long-term health consequences. University students are highly susceptible to adopting poor health-related behaviours, highlighting the vulnerability of this future generation. Combining research and the findings from this thesis, it is suggested that there is a lack of support for those at university with and without underlying health conditions. It is important to recognise that these populations, regardless of the nature of a university athlete, still require somewhat a level of supervision to ensure that they are conforming to recommended guidelines to avoid future health consequences. Interventions to achieve this may involve targeting student support systems within universities to provide aid with a student's physical and mental health as well as consider the additional stresses for different subgroups.

11.1.3 Limitations

Throughout this thesis, there have been many limitations listed that contribute towards population, research design and data collection. Overall, the sample size within studies was highlighted as a key limitation and may have been responsible for inaccuracy of results especially relating to the university lifestyle and behaviours of those with T1D. The small number of participants makes it increasingly difficult to create accurate statements to correctly represent the wider population. Repeating this study to assess the level of significance more accurately would require the increased recruitment of a T1D university athlete population to gain a broader understanding of managing the condition at university.

Another limitation involves the absence of dietary information of the university population. In the presence of this research, it may have supported the findings more effectively where stronger associations for metabolic health measures and BC could have been formed. Nutrition acts as a key component when concerning a healthy active lifestyle but can develop long term health consequences if the education isn’t provided and poor habits are formed. Athletes source their growth, recovery, and activity from the consumption of the appropriate amount of nutrients, therefore, repeating this study would benefit from building research around typical dietary patterns with PA.

Lastly, due to the use of convenience sampling, self-selection bias may had led to inaccuracy. All validated questionnaires were self-reported. The nature of a self-reporting questionnaire opens up the participant to form negative opinions on the questions, potentially leading to the urge to answer questions based on what they think paints a good image on themselves. Questions associated with sensitive subjects may also encourage participants to not respond truthfully due to poor mental health and the stigma that surrounds exposing the negative traits associated. Repeating this study may benefit from the use of interview style questioning where more personal/sensitive approaches can be taken to gain more accurate representation of the nature of the questions. Additionally if questions are misunderstood, they could be explained to retrieve relevant responses from participants.

11.1.4 Future Research

To increase the accuracy of results and create more evidence-based assumptions, future research should consider methods of recruiting greater numbers of T1D university athletes. In terms of the research itself, future studies could investigate thorough factors concerning the transition period for university students. In addition to this, evaluate the effectiveness of student support services in place to lessen the potential negative impacts on university lifestyle. This research could further highlight the demographic group in question as inherently vulnerable regarding their quality of life. A potential increase in attention on university students could result in better student support when embarking on their studies to avoid worsening their overall health status.

Another idea for future research involves the consideration of longitudinal designs to monitor performance and health of T1D university athletes over a longer period and assess the challenges and adaptations they face compared to non-T1D university athletes. Longitudinal studies allow researchers to create a comparison between data and would be beneficial for analysing whether a participant's dietary intake and training programmes are optimising performance and reaching goals. Additionally, this would be beneficial to the T1D community to support athletes at university managing their condition and conducting strategies from data to better performance and aid this demographic by easing and improving diabetes management.

11.2 CONCLUSION

This thesis has investigated the physical and mental health of T1D university athletes. T1D is an autoimmune disease that is characterised by fluctuations in BG levels that require PA alongside strategies to improve health to optimise overall management. Chapter 2 raised concerns about university athletes failing to meet recommended guidelines in physical and mental health testing. A small sample size presented difficulties in forming definitive conclusions about the T1D university athlete, however, the findings reported the potential increased PA levels in MPA and VPA contributed to an assumed better quality of life for this demographic. Focusing on T1D university athletes, chapter 2 also highlighted a trend where the key problem area was associated with glucose management and therefore, in need of support. Similarly to chapter 2, chapter 3 had a small sample size that may have contributed towards the inaccuracy of results. However, assumptions could be made about the lack of support for T1D university athletes concerning the risk of hyperglycaemia and its development of chronic diseases such as cardiovascular disease. This is because Chapter 3 highlighted a significant difference was in HbA1c and BG between T1D and non-T1D university athletes. This investigation into the level of support that is granted to T1D university athletes needs further attention as well as on university athletes in general when concerning meeting the guidelines for behaviours impacting overall health status. Further research is needed to determine the impact on physical and mental for T1D university athletes and whether the university lifestyle poses more of a threat to general health or the overall management of their condition.

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13 APPENDICES

13.1 APPENDIX A: QUESTIONNAIRE STUDY 1 (CHAPTER 2)

What is your full name?

____

What is your age?

____

Height (cm)

____

Weight (kg)

____

What university do you go to?

____

Do you suffer from any underlying health conditions?

○ Yes

○ No

Do you partake in any of the following?

☐ Smoking/Vaping

☐ Drinking Alcohol

☐ Taking any form of drugs (recreational and/or performance enhancing)

☐ None of the above

What underlying health conditions do you suffer with?

- ☐ Type 1 Diabetes
- ☐ Type 2 Diabetes
- ☐ Asthma
- ☐ Cardiovascular/ Heart Disease
- ☐ Arthiritis
- ☐ Mental Health Disorders
- ☐ Other ____

Does suffering with this condition highlight any barriers for you regarding physical activity and/or nutrition at university?

- ○ Yes
- ○ Maybe
- ○ No

What system do you currently use to manage your diabetes? (insulin pens, pump)

____

How do you typically treat hypoglycaemia?

____

How do you typically treat hyperglycaemia?

____

Do you adapt your food intake and/or diabetes management style when exercising?

- ◯ Yes
- ◯ No

What changes do you make to your diabetes management when planning to exercise?

____

What is your main sport/form of exercise?

____

What is your preferred type of exercising?

- ◯ Strength and Conditioning
- ◯ Sports Specific
- ◯ Cardio
- ◯ Weight Training
- ◯ Other (please state) ____

Outside your university participation in sport, do you take part in another club or exercise group?

- ◯ Yes
- ◯ No

Can you write a brief summary of what exercise you participate in outside university?

____

Do you feel it is important to regularly partake in a form of exercise?

- ◯ Yes
- ◯ No

In a few words, can you explain why you think it is important to regularly participate in exercise?

____

International Health Questionnaire (validated)

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 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. Think only about 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 activities like heavy lifting, digging, aerobics, or fast bicycling

	Not Applicable 0 1 2 3 4 5 6 7
How many days per week?	

In hours and minutes, how much time did you usually spend doing vigorous physical activities on one of those days?

____

Think about all the moderate activities that you did in the last 7 days. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about 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, bicycling at a regular pace, or doubles tennis? Do not include walking.

Not Applicable

0 1 2 3 4 5 6 7

How many days per week?	

In hour and minutes, how much time did you usually spend doing moderate physical activities on one of those days?

____

Think about the time you spent walking in the last 7 days. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

Not Applicable

0 1 2 3 4 5 6 7

How many days per week?	

In hours and minutes, how much time did you usually spend walking on one of those days?

____

The last question is about the time you spent sitting on weekdays during the last 7 days. Include time spent 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.

In hours and minutes, during the last 7 days, how much time did you spend sitting on a weekday?

____

End of International Physical Activity Questionnaire

What food group does your diet mainly consist of?

- ○ Carbohydrates
- ○ Proteins
- ○ Fats
- ○ Vitamins and Minerals

What meals do you regularly eat in the day when you are physically active? What do you typically eat at those meal times?

- ☐ Breakfast ____
- ☐ Lunch ____
- ☐ Dinner ____
- ☐ Snacks ____

What meals do you regularly eat in the day when you are NOT physically active? What do you typically eat at those meal times?

- ☐ Breakfast ____
- ☐ Lunch ____
- ☐ Dinner ____
- ☐ Snacks ____

Are aware of the nutritional values of the typical foods that you intake?

- ○ Yes
- ○ No

Do you use any fitness apps? (eg. calorie counters and progress trackers)

- ○ Yes
- ○ No

How many grams of carbohydrates do you consume daily?

____

How much sleep, on average, do you get each day?

- ○ < 5 hours
- ○ 5-7 hours
- ○ 7-9 hours
- ○ 9 + hours

How often do you feel tired?

- ○ All the time
- ○ Sometimes
- ○ Not at all

How often do you go out/ socialise at university?

- ◯ Once a week
- ◯ Twice a week
- ◯ 3 times a week
- ◯ 4 + times a week

Do you think the university lifestyle contributes towards your tiredness?

- ◯ Definitely not
- ◯ Probably not
- ◯ Might or might not
- ◯ Probably yes
- ◯ Definitely yes

Regarding the university lifestyle, what is the main factor contributing towards your tiredness?

- ◯ Going out and socialising
- ◯ Assignments
- ◯ Travelling
- ◯ Attending lectures and seminars
- ◯ Other (please state) ____

What mental health disorders have you been diagnosed with?

____

Are you aware of the services in place at the university to support you and your wellbeing?

- ○ Yes
- ○ No

Patient Health Questionnaire (validated)

Over the last 2 weeks, how often have you been bothered by any of the following problems?

	Not at all	Several Days	More than half the days	Nearly every day
1. Little interest or pleasure in doing things	○	○	○	○
2. Feeling down, depressed, or hopeless	○	○	○	○
3. Trouble falling or staying asleep, or sleeping too much	○	○	○	○
4. Feeling tired or having little energy	○	○	○	○
5. Poor appetite or overeating	○	○	○	○
6. Feeling bad about yourself - or that you are a failure or have let yourself or your family down	○	○	○	○
7. Trouble concentrating on things, such as reading the newspaper or watching television	○	○	○	○
8. Moving or speaking so slowly that other people could have noticed. Or the opposite - being so fidgety or restless that you have been moving around a lot more than usual	○	○	○	○

9. Thoughts that you would be better off dead, or hurting yourself.	○	○	○	○
10. If you checked off any problems, how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?	○	○	○	○

End of Patient Health Questionnaire

Diabetes Self-Management Questionnaire (validated)

The following statements describe self-care activities related to your diabetes. Thinking about your self-care over the last 8 weeks, please specify the extent to which each statement applies to you.

	Applies to me very much	Applies to me to a considerable degree	Applies to me to some degree	Does not apply to me
I check my blood sugar levels with care and attention	○	○	○	○
The food I choose to eat makes it easy to achieve optimal blood sugar levels.	○	○	○	○
I keep all doctors' appointments recommended for my diabetes treatment.	○	○	○	○
I take my diabetes medication (e. g. insulin, tablets) as prescribed.	○	○	○	○
Occasionally I eat lots of sweets or other foods rich in carbohydrates.	○	○	○	○
I record my blood sugar levels regularly (or analyse the value chart with my blood glucose meter).	○	○	○	○
I tend to avoid diabetes-related doctors' appointments.	○	○	○	○
I do regular physical activity to achieve optimal blood sugar levels.	○	○	○	○

I strictly follow the dietary recommendations given by my doctor or diabetes specialist.	○	○	○	○
I do not check my blood sugar levels frequently enough as would be required for achieving good blood glucose control.	○	○	○	○
I avoid physical activity, although it would improve my diabetes.	○	○	○	○
I tend to forget to take or skip my diabetes medication (e. g. insulin, tablets).	○	○	○	○
Sometimes I have real ‘food binges’ (not triggered by hypoglycaemia).	○	○	○	○
Regarding my diabetes care, I should see my medical practitioner(s) more often.	○	○	○	○
I tend to skip planned physical activity.	○	○	○	○
My diabetes self-care is poor.	○	○	○	○

End of Diabetes Self-Management Questionnaire

Problem Areas in Diabetes Scale (validated)

Which of the following diabetes issues are currently a problem for you? Tick the box that gives the best answer for you. Please provide an answer for each question.

	Not a problem	Minor problem	Moderate problem	Somewhat serious problem	Serious problem
Not having clear and concrete goals for your diabetes care?	○	○	○	○	○
Feeling discouraged with your diabetes treatment plan?	○	○	○	○	○
Feeling scared when you think about living with diabetes?	○	○	○	○	○
Uncomfortable social situations related to your diabetes care (e.g. people telling you what to eat)?	○	○	○	○	○
Feelings of deprivation regarding food and meals?	○	○	○	○	○
Feeling depressed when you think about living with diabetes?	○	○	○	○	○
Not knowing if your mood or feelings are related to your diabetes?	○	○	○	○	○

Feeling overwhelmed by your diabetes?	○	○	○	○	○
Worrying about low blood glucose reactions?	○	○	○	○	○
Feeling angry when you think about living with diabetes?	○	○	○	○	○
Feeling constantly concerned about food and eating?	○	○	○	○	○
Worrying about the future and the possibility of serious complications?	○	○	○	○	○
Feelings of guilt or anxiety when you get off track with your diabetes management?	○	○	○	○	○
Not accepting your diabetes?	○	○	○	○	○
Feeling unsatisfied with your diabetes physician?	○	○	○	○	○
Feeling that diabetes is taking up too much of your mental and physical energy every day?	○	○	○	○	○

Feeling alone with your diabetes?	○	○	○	○	○
Feeling that your friends and family are not supportive of your diabetes management efforts?	○	○	○	○	○
Coping with complications of diabetes?	○	○	○	○	○
Feeling burned out by the constant effort needed to manage diabetes?	○	○	○	○	○

End of Problem Areas in Diabetes Scale

Would you be interested in participating in a body composition and metabolic health research study at the University of Essex?

○ Yes

○ No

Please can you provide your email address.

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Thank you for your interest in our survey. As you have not provided Consent, you will not be asked to complete the survey.