Self-Regulation and Type 1 Diabetes: Links to Disordered Eating, Condition Management, and Insulin Omission for Weight Loss

By

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Declaration

I declare that this thesis is entirely my own work, completed under the supervision of Dr Michelle P. S. To and Professor Sandra-Ilona Sünram-Lea. No part of this thesis has been submitted elsewhere in support of application for the award of a higher degree.

Signed:

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Abstract

The focus of this thesis was to explore the role of self-regulation (SR), that is the ability to monitor and regulate emotions and behaviours, in type 1 diabetes (T1D) management and the development of disordered eating behaviours (T1DE) and insulin omission as a method of weight loss (IO) among women with T1D. Researching the relationship between type 1 diabetes and the psychological and social moderating or mediation factors in developing an eating disorder is of high importance as the prevalence of T1DE and IO is up to 60% in women with T1D, and eating disorders in this population are associated with significant long-term morbidity and mortality risks. Moreover, deficits in SR have been identified among individuals with eating disorders such as anorexia nervosa and bulimia nervosa, and other chronic health conditions including asthma. In this thesis the hypothesis that the consistent demand that T1D management has on SR, due to the need to frequently monitor blood glucose readings, calculate carbohydrate consumption and appropriate insulin dosages, results in deficits in SR which increases susceptibility in women with T1D to developing T1DE and IO. Potential moderating or mediating factors were explored, such as the role of carbohydrate counting and food perceptions and social support. Overall, the results from the four studies conducted as part of this thesis provide evidence for the role of SR deficits in the development of T1DE and IO. Furthermore, the results suggest that carbohydrate counting *per se* does not play a key role in the depletion of SR in women with T1D, but that key factors appear to be dietary restraint and the implications on blood glucose. The drain on cognitive capacity, and reduced feelings of self-efficacy, were also found to mediate condition management. Reductions in these facets led to negative self-talk and feelings of burnout which increased the likelihood of disengagement. The findings of this programme of research should inform future research to further increase our understanding of how implementing SR interventions among individuals with T1D could

inform good practise in the management of TIDE and potentially reduce incidences of T1DE and IO.

Contents

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Chapter 1

1. Introduction

1.1 Background and Context of Research

Social cognitive theory has played a major role in shifting the field of health from a disease model to a health model that focuses on disease prevention and health promotion (Bandura, 2005). Promotion of good health begins with setting goals (Nordin, 1999) and attaining long-term goals requires the implementation of self-regulation (SR). SR enables individuals to regulate and adjust their behaviours and emotions to remain in line with their goals (Nigg, 2017). Having sufficient ability and capacity to self-regulate is therefore paramount to leading a healthier and, by association, happier, life (Bandura, 2005; Cloninger & Zohar, 2011).

SR deficits have been suggested to lead to significant psychological distress and have been demonstrated to play a role in the development of a number of mental health conditions, including addiction (Zucker et al., 2011), depression (Wang et al., 2015), anxiety (Salters-Pedneault et al., 2006), and various eating disorders (Goodsitt, 1983), including anorexia nervosa (Karwautz et al., 2001; Beadle et al., 2013) and bulimia nervosa (Schupak-Neuberg & Nemeroff, 1993).

Interestingly, eating disorders have been found to be more prevalent in people living with chronic physical health conditions (Cadman et al., 2012), particularly those with type 1 diabetes (T1D). T1D is a chronic health condition which is caused by the destruction of insulin secreting cells of the pancreas (Bluestone et al., 2010; Todd, 2010). The condition necessitates high daily SR demands, given the need to frequently monitor blood glucose levels, observe carbohydrate consumption, and calculate insulin dosages accordingly. In addition, other factors that can affect glucose regulation have to be considered, such as exercise, hormonal changes, and even weather conditions. On top of daily monitoring, individuals also have to manage the

physical and psychological impact of hypoglycaemia (low blood glucose) and hyperglycaemia (high blood glucose). Sufficient SR is therefore paramount in successful daily T1D management, and overall health. As stated, studies have illustrated an increased rate of particular mental health disorders among patients with T1D, particularly depression (Buchberger et al., 2016) and bulimia nervosa (BN; Mannucci et al., 2005); a condition categorised by binging large quantities of food, followed by purging by means of self-induced vomiting or laxatives (National Health Service, 2017). Individuals with T1D, however, have the ability to purge in another unique way, which is insulin omission. Over recent years there has been increased concern over the prevalence of insulin omission as a method of weight loss (IO).

IO is a highly dangerous behaviour available to people with T1D, and is highly associated with type 1 diabetes disordered eating (T1DE). It ensues when the hormone insulin is purposely reduced or omitted, resulting in increased blood glucose levels which in a fairly short time can lead to significant weight loss. However, engaging in such behaviour can lead to severe health complications, including retinopathy, neuropathy, and nephropathy, as well as early mortality. Previous research has shown that as many as 60% of people with T1D have engaged in IO in the past (Deiana et al., 2016). Understanding the cognitive factors which lead to the development of this behaviour in T1D patients is crucial to the development of educational material targeted at reducing this behaviour, and thus potentially saving lives.

The following chapter will provide a literature review of SR; exploring the concept of self-regulation to gain an appreciation of its complexity and identifying points at which insufficient development may lead to SR deficits. Following this, the causes and effects of SR deficits will be explored, with particular interest given to its role in eating behaviours and the mental health conditions found to be associated with such deficits. Furthermore, an overview of T1D and its management requirements will be provided, along with the complications which

can occur without adequate management of the condition. The relationship between T1D and an array of mental health conditions will also be discussed, and the role SR capacity plays in T1D management will be explored. T1D and disordered eating (T1DE) and IO will then be examined further, and an argument will be made to suggest that deficits in SR predict incidences of T1DE and, moreover, IO.

1.2 Unity of Approaches and Themes

This thesis was designed to investigate the role of SR in the development of disordered eating and insulin omission in women with T1D in a variety of ways. Both quantitative measures of explicit and implicit attitudes were assessed through the use of questionnaires and evaluative priming, respectively. Furthermore, qualitative analysis of reports from women with T1D has been conducted allowing a richer and more succinct understanding of the role of SR in condition management. All of these approaches have therefore been used together to allow a richer understanding of the role that SR plays in the management of T1D in women, with particular focus on insulin omission for weight loss.

1.3 Rationale for Submission of Thesis in Alternative Format

Each of the studies conducted as part of this thesis holds strong academic merit and could lead to significant real-world implications. For that reason, each of the studies has been written up in a format which is ready for submission to suitable journals, therefore allowing their findings to be broadcast among the greater scientific community.

1.4 Construction of the Alternative Format Thesis

The present thesis is divided into several sections, each of which follows on from the previous chapter. Following the introduction, the literature review aims to provide a detailed account of the concept of SR, the role SR pays in the development of disordered eating and its links to

living with T1D , with the intention of highlighting the necessity of the programme of research presented in this thesis.

This is followed by paper 1 which aimed to investigate the role of SR in relation to eating behaviours and body satisfaction in the general population. This paper was initially developed due to the restrictions put in place because of COVID-19. However, it allowed for a better understanding of the part SR plays in developing negative eating attitudes and body dissatisfaction among women in the general population (i.e. without T1D), and therefore provided a baseline which the results found in paper 2 could be compared.

Paper 2 was designed to gain an explicit account from women with T1D regarding their SR capacity. Moreover, it allowed for examination of the effects of SR on eating attitudes and T1D management, in particular its effect on risk of engaging in IO. Based on the results of paper 1 and paper 2, evidence suggested that SR is significantly lower in women with T1D compared to women without T1D (general population), and that this deficit may be a strong mediating factor in the development of T1DE and IO.

Paper 3 was developed to examine whether these SR deficits are related to the daily demands of carbohydrate counting, and whether this demand was linked to an implicit bias towards food. Since consumption of high carbohydrate foods requires a person with T1D to exhibit significant SR control to calculate the required insulin administration, a negative implicit bias towards these foods may be linked to depleted SR capacity.

Paper 4 was designed to allow women with T1D the ability to provide their own account of living with the condition, and highlight factors that they felt were important in its management. This included evaluation of behaviours which might result in SR depletion. This ensured that the results collected from the quantitative studies were reflective of true, lived

experiences of managing the condition. Based on the interview results, this paper provided methodologically different but ultimately concurrent findings to the previous studies.

Chapter 2

Self-Regulation and Type 1 Diabetes: Links to Disordered Eating, Condition Management, and Insulin Omission for Weight Loss

Literature Review

2.1 Self-Regulation

2.1.1 Origins of Self-Regulation

Self-regulation (SR) is a term which refers to the executive functioning mechanism of managing behaviours and emotions to achieve long term goals (Nigg, 2017). It is considered a core aspect of human behaviour, and has been studied across numerous areas of psychology including social, personality, and cognitive psychology (Hofmann et al., 2012). Early research into the development of self-regulatory control differed drastically between operant behavioural and psychoanalytical standpoints. Operant behaviour is behaviour whose occurrence depends on the environmental consequences it produces and thus operant behavioural theorists like Skinner (1938) believed that SR is a behaviour whose occurrence depends on the resulting environmental outcomes. More specifically, self-control results from positive reinforcement in social environments (i.e. operant conditioning), leading to the adoption of advantageous behaviours. This theory, however, has been challenged as research has demonstrated the presence of SR behaviour in the absence of external reinforcement (Bandura & Walters, 1977).

Psychoanalytical theorists like Freud (1936) had strongly opposing views to Skinner (1938), and saw the ability to self-regulate as one of a number of 'basic drives' that humans are born with. The 'id', 'ego', and 'superego', as described by Freud, would allow humans to juggle individual desires and the moral standards set by society. However, there has been little evidence to adequately support Freud's theory.

Much of what we now know about SR and its functions stems from Bandura's (1986; 1991) work on social cognitive theory. He states three principle functions of SR:

1. The monitoring and maintaining of standards of one's own behaviour and emotions, and their effects.

2. The judgement and motivation to alter one's own behaviour and emotions with regards to the standards one individually endorses.
3. The capacity to automatically compensate or adjust one's behaviour and/or emotions despite obstacles or temptations.

SR therefore provides the fundamental basis of one's actions. Without sufficient standards and monitoring, without the motivation to change, or without the capacity to change, SR deficits are likely to occur (Hofmann et al., 2012).

2.1.2 Progression of Self-Regulation Through Childhood and Adolescence

Developing effective SR skills has repeatedly been recognised as a marker of success in later life, with early childhood development often considered fundamental (Calkins, 2007; Moffitt et al., 2011; Vohs & Baumeister, 2011). Neural maturity of the prefrontal cortex (PFC) plays a vital role in its development, as various separate skills such as inhibitory control and emotion regulation become organised and integrated, through the formation of functional white matter connections (Fiske & Holmboe, 2019). Research suggests that prior to 3 years old, children have difficulty coordinating these skills simultaneously due to their lack of motor and verbal control (Carlson et al., 2002; Zelazo et al., 2003). Past the age of 3, however, children should generally have acquired the necessary basic skills to enact SR (Montroy et al., 2016). The strength of the connections of the white matter tracts which connect the PFC to other brain areas have been suggested to predict developmental success in executive functioning (Woodward et al., 2011), which is said to be the agent which alters behaviours and decisions, and thus an important cognitive component of SR (Baumeister et al., 2007).

Schunk and Zimmerman (1997) demonstrated that the development of SR in children is largely grounded in social origins, whereby children are influenced and internalise concepts,

attitudes, and preferences through observational learning (i.e. modelling). They then learn to apply these concepts through trial and error in order to develop SR capacity (Zimmerman, 2002). Through having robust and effective models, children develop greater capacity to achieve self-efficacy and SR. This is particularly important as self-efficacy and goal-achievement are strongly interlinked based on social cognitive theory (Bandura, 1986), as being self-efficacious (principle 1) influences motivation (principle 2), and vice versa. Komarraju and Nadler (2013) provided strong evidence of this effect by examining academic achievement in undergraduates, and found that levels of self-efficacy were important in predicting academic achievement, whilst also illustrating that students with high self-efficacy were more likely to persist through more difficult academic material.

The influence of environmental factors on SR development continues into adolescence. In a review of the literature examining adolescent SR development, Farley & Kim-Spoon (2014) suggested the strong influence that relationships with parents, peers and friends, and romantic connections have on its development, suggesting a bidirectional relationship between these connections and the appropriate development of SR during adolescence. The importance of these relationships and the impact that they have on SR development changes as adolescents get older, whereby family relationships play a greater role during early adolescence, whereas peer support and romantic relationships have a stronger contribution during late adolescence and early adulthood (Seiffge-Krenke, 2003).

Adolescence is a particularly crucial time in self-regulatory development, given the rapid changes which begin to occur physically, mentally, and socially. Being able to sufficiently self-regulate has been shown to improve academic performance (Blair & Diamond, 2008), increase levels of prosocial behaviour (Bandura et al., 2001) and reduce risky behaviours such as substance use (Jessor & Jessor, 1977; Kirby et al., 1999). However, the increased cognitive and social demands which occur during this period force adolescents to

adapt, and develop “intentional SR” (Gestsdottir & Lerner, 2008). This refers to the ability to contextualise actions which are actively targeted towards balancing personal demands with self-sought achievements, and is characterised by an increase in goal-directed behaviours.

Despite this, deficits in enacting SR are frequently observed in adolescents, often manifesting as externalising or aggressive behaviours (Constanty et al., 2021). Casey and Caudle (2013) argue that issues with SR during adolescence stem from the fact that, relative to children and adults, the ability to appropriately impulse control during adolescence is severely taxed, due to the fact that there is less top-down control in the reward-related circuity of the prefrontal connections within the teenage brain. This is generally considered a primal cause for much of the dysfunctional behaviours seen during adolescence, as the balance between increased SR demands and capacity for SR behaviour is skewed. In other words, adolescents may display deficits in SR due to insufficient standards and monitoring, lack of motivation to change, or lack of skills or capacity to change (Bandura, 1991).

Into adulthood, there are also a number of other factors thought to impact the ability to adequately self-regulate. Self-efficacy, that is, having the belief in oneself to be able to learn and perform effectively (Bandura, 1997), has been illustrated as being strongly linked to the ability to manage emotions and behaviours (Schunk, 1990). Komarraju and Nadler (2013) provided strong evidence to this effect by examining academic achievement in undergraduates, and found that levels of self-efficacy were important in predicting academic achievement, whilst also illustrating that students with high self-efficacy were more likely to persist through difficult academic material. Low levels of self-efficacy may therefore reduce the ability to effectively self-regulate. Perceived inefficacy has also been demonstrated as a factor in the development of depression (Bandura et al., 1999), which could indicate the role of SR deficits in the development of a number of mental health conditions.

2.1.3 Self-Regulation and Emotions

While emotions do not generally directly control behaviour (although they sometimes can), Baumeister and colleagues (2007) hypothesised that emotion serves as a feedback source following a behaviour, meaning that once a behaviour has been actioned and any subsequent consequences faced, an emotion provides an evaluation of the whole event (Tice, 2009). This feeds into the observational learning previously mentioned, which can have an impact on future behaviour. Thusly, emotions can have a great influence on the SR process, and more specifically emotional distress can cause SR failure (Baumeister et al., 2007). However, this relationship is not causal. Baumeister and colleagues (2007) demonstrated this through a series of studies whereby SR tasks were provided to participants in various affective states. Sad participants demonstrated significantly greater reduction in SR in a variety of delayed gratification and procrastination tasks, but the researchers claimed that it was not the negative state itself that caused this deficit. Instead, these SR failures were only encountered because the sad participants had reason to believe that acting in this way would improve their emotional state (for example, drinking alcohol would serve to improve their mood). As such, a lack of self-efficacy in task performance as a result of low mood may have led to these SR failures (Bandura et al., 1999).

2.1.4 Self-Regulatory Deficits

Deficits in SR will reduce an individual's capacity to amend their motivations, emotions, and behaviours to enable them to achieve their long-term goals. Based on the three principles of social cognitive theory suggested by Bandura (1986; 1991), Baumeister and Heatherton (1996) described failures in SR as being the result of a deficit in one or more of these areas: standards

and goal monitoring, judgements and motivation, and capacity to correct. Therefore, an SR failure may occur due to standards that are too high or low, or due to the fact that no standards have been set. In addition, deficits could result from conflict between standards and desired goals, or a failure to monitor states of self which leads to a lack of awareness of discrepancy between desired state and actual state. Moreover, lack of motivation to enact a change, or lack of capacity to actually enact a change might also result in a failure to appropriately enact SR(MacCoon et al., 2004).

Deficits in SR are thought to, in part, be a result of a lack of capacity as mentioned above. The PFC, which plays a strong executive role in the control and capacity of SR, is also still developing during adolescence. While the size of the cerebral cortex actually decreases between ages 12 and 22 (Giedd et al., 1999), neuroimaging has shown that the pathways within the PFC do not fully mature until the early 20s (James-Roberts, 1979). However, by this point into adulthood the PFC should be fully developed, and individuals should have had enough environmental exposure to appropriately develop their own standards and motivations. Despite this, SR deficits have been implicated in a wide variety of 'undesirable' behaviours in adults, from overeating and failure in maintaining diet and lifestyle changes, to those more serious like addiction, alcoholism, depression, anxiety, and eating disorders (Johnson et al., 2012; Leehr et al., 2015; Salters-Pedneault et al., 2006; Schupak-Neuberg & Nemeroff, 1993; Wang et al., 2015; Zucker et al., 2011)

2.1.5 Strength Model of Self-Control

One potential explanation of such SR deficits comes from an influential theory from Baumeister and colleagues (1994) known as the 'strength model of self-control'. Based on the fundamental principles of social cognitive theory (Bandura, 1989), the model poses that self-

control is a finite resource (thought to be glucose), and engaging in a task with high SR demand causes a depletion to this resource. This then leads to impaired self-control on a subsequent task and subsequent SR failures known as 'ego depletion' (Baumeister et al., 2007). The model also proposes that SR strength will improve over time if repeatedly applied, in the same vein as muscles get stronger with frequent exercise (Baumeister & Vohs, 2016).

The model was developed based on a seminal experiment where participants were required to conduct two SR demanding tasks in succession (Baumeister et al., 1994). Adult participants were allocated to one of three conditions: the 'chocolate chip cookie' condition, the 'radish' condition, or a control condition. Both experimental groups were asked to sit at a table containing freshly baked cookies on one side, and a bowl of radishes on the other. Participants in the cookie condition were asked to eat at least three cookies, while participants in the radish condition were asked to eat at least three radishes. The control group did not take part in this task. Participants were then asked to complete a problem-solving task which was impossible to solve. The authors predicted that participants in the radish condition would have exerted significantly greater SR in the first task to stop themselves from eating the cookies, and as such would spend less time on, and make fewer attempts to complete, the problem-solving task. The results supported this hypothesis, and provided initial support for the strength model and the proposal that SR is a finite, exhaustive resource.

Since then, over 600 experiments have provided support for the strength model (Cunningham & Baumeister, 2016). In a meta-analysis of 83 studies looking at the effect of ego depletion on subsequent task performance, Hagger and colleagues (2010) found significant evidence supporting the hypothesis, with large effect sizes found for a number of measures including effort, perceived difficulty, and blood glucose levels. Their results therefore provided support for the idea of SR being a finite source which can become depleted, and that this has an impact on subsequent tasks.

2.1.6 Chronic Ego Depletion

However, despite its influence and repeated replication, the strength model of self-control is not without its limitation. One such limitation is that studies have generally only examined it through use of a sequential task paradigm, whereby a task demanding high levels of SR is immediately followed by a second similarly demanding task immediately afterwards (Tyler & Burns, 2008). The question that cannot be answered using this experimental paradigm is how long this depletion lasts, and what is the impact on SR among individuals who have to enact high levels of SR for long periods of time.

Vohs and Heatherton (2000) presented evidence which suggested that depleted SR as a result of chronic dieting was associated with disinhibition around snacks. Wang and colleagues (2015) also attempted to address this by examining a theory of 'chronic' ego depletion. Over a period of 3 weeks, the researchers asked a group of students to complete a version of the self-regulatory fatigue scale (Nes et al., 2013) as a measure of chronic ego depletion, as well as outcome measures of their daily performance, mental effort, and motivation towards goal-directed behaviour. They found that chronic ego depletion significantly increased SR failures, as those in a chronic state of SR fatigue were less likely to attain their long-term goals. However, as participants only completed the self-regulatory fatigue scale once, and not over the three week period, it is difficult to conclude the stability of these results over time.

2.1.7 Limitations of Ego Depletion

Despite the number of studies which have replicated the strength model of self-control and found evidence of ego depletion (Baumeister et al., 2007), there is still a large amount of scepticism within the scientific community regarding the validity of the hypothesis. A number

of studies have failed to replicate the initial results, with some researchers calling ego depletion 'one of the chief victims of the replication crisis' which is now facing social psychology and science in general (Inzlicht & Friese, 2019).

In a meta-analysis by Carter and colleagues (2015), which looked to extend the one previously conducted by Hagger et al. (2010), they found little evidence to suggest that the phenomenon of ego depletion exists. Cunningham and Baumeister (2016) have queried these findings, however, noting that a number of published studies had been excluded from Carter et al.'s (2015) analysis, while a number of unpublished studies were included as part of the analysis. The inclusion of unpublished studies in Cater et al.'s meta-analysis can however be seen as a strength, as a way of reducing publication bias. Hagger and colleagues (2010) did not include unpublished studies or account for overestimation of effect size estimates (Inzlicht & Friese, 2019). Following this criticism, Hagger and colleagues (2017) conducted a further multi-lab (27 labs in total) study to examine the ego depletion effect and indeed found that the size of the effect was small, and its 95% confidence intervals encompassed zero, meaning there is no statistically meaningful difference between groups

In an attempt to settle the debate, Friese and colleagues (2019) looked at both sides of the argument, examining whether there is sufficient evidence for or against the case of ego depletion. They concluded that, despite the hundreds of studies published, the evidence remains inconclusive.

2.1.8 Alternative Theories of Self-Regulation

Given the controversy surrounding the strength model (Baumeister et al., 2007), alternative theories have since been developed, including the resource allocation model (Beedie and Lane,

2012), the shifting priorities model (Inzlicht et al., 2014) and the need-to-belong theory (Baumeister, 2012).

Contrary to that put forth by the strength model, evidence has suggested that if an individual is high in motivation, they appear to perform a self-control task well despite prior exertion (Baumeister & Vohs, 2016). An alternative theory proposed by Beedie and Lane (2012), and counteracting the basis of the strength model whereby SR relies on a finite resource, the resource allocation model suggests that it is a matter of allocation of glucose within the brain which impacts the ability to effectively enact SR. They pose that if a task is not viewed as a priority to an individual, meaning it is not deemed important or interesting, then glucose will not be attributed to that task leading to a subsequent SR failure. Based on this theory, when motivation to conduct a task is high, this ought to then result in increased blood glucose (BG) concentrations, and thus suggesting that the allocation of glucose directly impacts the capability to enact SR.

Another theory that proposes an alternative to the idea of SR as a limited resource is Inzlicht and colleagues' non-resource-dependent account of self-control where failures in SR are thought to be caused by the switching of motivation from one task to another (Inzlicht et al., 2014). The researchers proposed that when SR failures occur, this reflects an individual's attempt to find balance between the cognitive labour necessary to achieve mandatory goals, compared to the cognitive leisure of pursuing goals which are enjoyable and interesting. Based on this theory, reductions in SR are the result of a shift in priorities (Masicampo et al., 2014).

Evidence has been found in support of this theory by Werle et al. (2014), who manipulated the wording of task instructions to be perceived as fun rather than a chore (e.g. labelling a walk as 'scenic' rather than 'exercise'). They found that those who perceived the task as fun consumed less dessert and fewer snacks after the walk, suggesting that engaging in

physical activity triggers the search for a reward if the activity is perceived as exercise but not when it is perceived as fun. This supports the shifting priorities model, as following a task perceived as high in cognitive labour an individual will seek to balance the mental load with a leisurely activity, resulting in SR failure. This model is also linked to the previously mentioned research around emotions and SR, as those in a negative affective state may shift their priorities in an effort to feel better (Baumeister et al., 2007).

From a more social perspective, Baumeister and colleagues (2005) found evidence to suggest that social exclusion may be a factor that impairs SR, resulting in the need-to-belong theory (Baumeister, 2012; Baumeister & Leary, 1995). They observed that participants who were made to feel socially isolated, often lacked the motivation to enact SR despite still having the capacity. Cited over 2000 times, demonstrations of the need-to-belong theory and SR deficits as a result of social isolation have been widely replicated across various demographics. For example, Stenseng and colleagues (2014) conducted a longitudinal study to examine the impact that social isolation had on the SR development in children between the ages of 4 and 6 years old. Their data demonstrated that children who faced social isolation in school demonstrated SR deficits, which in turn predicted further social exclusion. Similar results were demonstrated in young adults, whereby feelings of ostracism and social exclusion were associated with impairments in SR (Oaten et al., 2008).

2.1.9 Self-Regulation and Chronic Physical Health Conditions

SR capacity has important implication for the management of chronic health conditions, as significant effort is necessary to manage such conditions. Clark and colleagues (2010) demonstrated that patients with asthma who followed a SR intervention programme had a reduced number of hospital visits and improved quality of life compared to those without

intervention. Clark et al. (2014) proposed a model of disease management, underpinned by social cognitive theory (Bandura, 1986, 1991), whereby an individual's ability to achieve optimal management of their condition was influenced by their SR ability. Their model also highlighted the importance of both intrapersonal and external factors in altering management strategies, which intend to improve outcome for the patient. Among a cohort of children with asthma and their caregivers, the model was found to be longitudinally stable. Similarly, among individuals with epilepsy, Rizou et al. (2017) demonstrated that a SR intervention for children was beneficial in reducing psychological distress and sleep problems. This in turn reduced the number of seizure incidences, and therefore improved quality of life (Vaughn & O'Neill, 2004).

In a review of the literature, Lansing and Berg (2014) identified a number of similar factors, including self-efficacy, treatment adherence, and external support, which served to increase risk and resilience of chronic illness self-management among adolescents. In a model adapted from Modi and colleagues (2012), the researchers also proposed that SR appears to underpin both intrapersonal and interpersonal factors of the self-management of chronic illnesses. They also highlight the body of literature which demonstrates that deficits in executive function (defined as "cognitive abilities necessary for orchestrating and actioning goal-directed behaviour"; Blair & Ursache, 2011, p. 300) have been associated with reduced self-management capacity of chronic illnesses (O'Hara & Holmbeck, 2013); providing further support that SR is an important foundation in the management of chronic illness.

Living with a chronic illness can often make an individual feel isolated from society, which in turn could result in lack of necessary motivation to enact sufficient SR needed to manage their condition appropriately (Baumeister et al., 2005). Based on the need-to-belong-theory mentioned earlier, social isolation as a result of living with a chronic illness (Hysing et al., 2007; Lavigne & Faier-Routman, 1992) can negatively impact SR. Moreover, living with

a chronic illness has also been linked to higher levels of negative emotions and feelings of resignation (Riva et al., 2017), which could lead to the development of mental health conditions. Identifying SR deficits in patients with chronic conditions could therefore be hugely important in the development of targeted SR interventions designed to improve condition management and quality of life.

2.1.10 Self-Regulation, Depression, and Anxiety

Effective SR relies on emotional stability in order to have the capacity to make rational decisions, and effectively control actions, to achieve a desired goal (Nigg, 2017). However, a number of mental health conditions are associated with emotional instability, which may indicate an association between poor mental health and SR deficits.

Depression is classified as a "distress disorder" (Watson, 2005), and patients with the condition have been found to display impaired cognitive function, particularly executive function (Austin et al. 2001; Kaiser et al., 2003; Landrø et al., 2001). It is unsurprising, then, that patients with depression have been found to show significant SR disturbances. Garnefski and Kraaij (2007) found strong relationships between a number of emotional SR strategies, including self-blame and rumination, and symptoms of depression (and anxiety) both on first test and at follow-up. Similarly, Joormann and Gotlib (2010) found that depressed patients exhibited significant maladaptive emotion regulation strategies when presented with a negative affect priming task. This suggests that depressed individuals have deficits in cognitive control indicative of reduced SR. Furthermore, Spinhoven et al. (2017) recently illustrated that higher levels of SR may serve as a protective factor from relapse or reoccurrence of depression among a cohort of patients in recovery, indicating the role of SR deficits in the development and maintenance of depression. Evidence of SR disturbances in patients with depression have also been highlighted in neurocognitive research, where a number of studies have presented findings

consistent with the idea that serotonergic function is involved in the pathways which modulate impulse control (Boisvert et al., 2018; Carver et al., 2008; Carver et al., 2014; Crockett et al., 2010). One of the leading biological theories of depression suggests and imbalance in serotonergic activity and indeed selective-serotonin reuptake inhibitors are one of the most widely prescribed pharmacological interventions (Kerr, 1994). As the inability to control impulses is strongly associated with SR failure (Baumeister & Heatherton, 1996), there might be a link between serotonin and SR in depression.

Deficits in SR have also been identified among those who suffer with anxiety. Among a cohort of patients with general anxiety disorder, Salters-Pedneault and colleagues (2006) found evidence of a number of SR deficits including deficits in emotional awareness and acceptance, engagement in goal-directed behaviours, and impulse control. So prominent has the relationship between SR failures and anxiety become, that a model of emotion dysregulation was developed as a method of better understanding generalised anxiety disorder (Mennin et al., 2004). One possible explanation for this association between SR and living with these mental health conditions could come from the need-to-belong model. Living with a mental health condition is also often associated with feelings of social isolation (Boardman, 2011), and as such this may impede an individual's ability to enact SR.

To conclude, the ability to self-regulate is essential to attaining long-term goals (Nigg, 2017), and there are a number of theories which attempt to understand how individuals are able to enact SR. Deficits in SR have been linked to difficulties in emotional distress, as well as number of mood disorders examined above. There is also an evidenced link between SR and a number of chronic health conditions. The following section of the literature review will specifically focus on the relationship between SR, eating, and eating disorders. The SR literature and eating disorder literature will then be collated and explored in relation to type 1 diabetes and the development of disordered eating.

2.2 Self-Regulation, Eating, and Eating Disorders

2.2.1 Overview

Eating is one of life's most fundamental behaviours and essential for survival of the species. Initiation of eating behaviour is primarily driven by feelings of hunger but other factors play an important role. Blundell and Tremblay (1995) proposed an appetite control system which encompasses eating, hunger, and other physiological mechanisms like satiety response. Physiologically speaking, the body has developed a complex system which recognises when food is needed, the type of food required (as many cravings are recognised to be driven by internal signals of nutrient deficiency; Steel et al., 2006), and when sufficient amounts of food have been consumed. However, this system fails to explain circumstances such as overeating, binging, and deliberate severe food restriction, suggesting that maintaining energy balance and controlling body weight involves much more than monitoring bodily energy reserves and the detection of physiological signals that tell when we are hungry or sated (Davidson et al., 2019).

Research has demonstrated the importance of cognitive processes in the control of eating behaviour. Deficits in SR have been suggested to be one cognitive process that might be involved in the development of disordered eating behaviour. For example, based on the restraint theory (Herman & Mack, 1975; Herman & Polivy, 2004), restrained eating behaviour involves higher-level cognitive processes to counter the power of food to evoke eating (Herman and Mack, 1975; Polivy and Herman, 1985). Excessive cognitive control over eating may deplete SR capacity, making people who restrict their food intake vulnerable to overeating due to SR failures. Ogden's (1994) review of the theory supported these findings, suggesting that restraint may have a detrimental impact on both physiological and psychological wellbeing. However, the direction of this relationship has been queried by some, as research has demonstrated that restraint theory only applies to dieters who already had a previous affinity for overeating (Van Strien et al. 2000).

Some chronic physical health conditions, such as type 1 diabetes (T1D), necessitate a high level of cognitive control over food intake to maintain optimal blood glucose levels. According to the restraint theory, this would suggest that those living with the condition may have a greater likelihood of overeating and weight gain (Kahkoska et al., 2017). However, scientific evaluation of this theory is currently extremely limited.

2.2.2 Dieting and Self-Control

Losing weight is a long-term goal which usually requires individuals to restrict and modify their food intake (diet). This often means having to forgo typically more desirable foods, such as those high in simple sugars and fats, and replace them with healthier alternatives. Maintaining a weight loss diet therefore requires a high level of SR control, as individuals must manage their impulses to give in to temptations if they are to achieve the desired weight loss and attain their goal weight. Although efforts to lose weight are often successful initially, most individuals fail to maintain this loss long-term (Elfhag & Rossner, 2005; Mann et al., 2007; Papies et al., 2008). A body of research has examined the link between dieting and SR, to assess whether SR deficits may play a role in dieting failures.

For example, an experiment by Vohs and Heatherton (2000) assessed the validity of the strength model and ego depletion hypothesis in dieting behaviour. Dieters and non-dieters were allocated to either a ‘strongly depleting’ (sitting close to a bowl of sweets) or ‘weakly depleting’ (sitting far away from the bowl of sweets) experimental condition. The results demonstrated that dieters in the ‘strongly depleting’ condition subsequently ate greater amounts of ice cream, and spent less time attempting a cognitively demanding task. This study illustrated that those who are consistently having to enact SR in order to maintain dieting behaviours may be more susceptible to SR failures. Therefore, persistent food-related

restriction may lead to reduced SR and subsequent failures to maintain healthy eating behaviours.

This finding was later confirmed by a review by Johnson and colleagues (2012), who found evidence to suggest that sustained self-regulatory effort to monitor and moderate food intake was characteristic of long-term weight maintenance, meaning that adequate SR is vitally important for those with weight-gaining tendencies.

2.2.3 Body Image in Disordered Eating

Although efforts to manage weight can be associated with factors such as health concerns, the primary reason for individuals to begin engaging in dieting behaviour is often due to a negative body image, which has been identified as a precursor for eating disorders (e.g. Stice & Bearman, 2001). Putterman & Linden (2004) found that women who were motivated to diet for appearance-related reasons reported greater body dissatisfaction, and were more likely to use unhealthy dieting strategies than women who were dieting for health-related reasons. Women who were dieting for appearance also reported more episodes of disinhibition in their eating habits, and greater lapses in restraint. This could therefore suggest a relationship between negative body image and SR deficits.

Deficits in body satisfaction are particularly common among women (Hall et al., 2021; Wardle & Johnson, 2002). Issues with body shape are also emerging early, with one study demonstrating that over half of girls aged 9 to 14 years of age wanted their body to be thinner (Dion et al., 2016). Body dissatisfaction is especially common among individuals with T1D (Markowitz et al., 2009; Troncone et al., 2020), which may be due to a variety of factors explored in greater detail later. This relationship between body image and T1D may provide further indication of deficits in SR among people with the condition.

2.2.4 Eating Disorders

An eating disorder (ED) is categorised by the Diagnostic and Statistical Manual of Mental Disorders (DSM-V; American Psychiatric Association [APA], 2013) as a behavioural condition which presents with severe, prolonged disturbances to eating behaviours, and is associated with emotional distress and negative thoughts. The development of disordered eating and subsequent EDs appears to initially stem from dieting behaviour (Hsu, 1989), and dieting behaviour and food restriction can become an problematic in particular if reducing food intake and exercising more frequently do not achieve the desired weight loss within a given time frame (Raynor et al., 2006). In a 5-year longitudinal study of adolescents, Neumark-Sztainer and colleagues (2006) found that participants who were engaging in dieting and unhealthy weight-control behaviours at baseline (but did not meet the diagnostic criteria for an ED) were at significantly greater risk of presenting with an ED, especially bulimia nervosa (BN), at follow-up.

This is of particular concern given that as many as 20-30% of adolescent girls may engage in unhealthy weight-control behaviours (Spear, 2006). The reasons behind such a large proportion of girls engaging in these behaviours are multifactorial, and likely include societal pressures (Siervo et al., 2014), media influence (Das et al., 2014), and family behaviours (Ata et al., 2007). However, in the context of the present research it is important to note that eating disorders (EDs) have been associated with deficits in SR capacity. 30 years ago, Goodsitt (1983) proposed that ED patients suffered with severe deficits in SR, and that the behaviours which they engaged with (starvation, vomiting, etc.) were “desperate measures to drown out states of overstimulation and/or fragmentation” (Goodsit, 1983). In the following sections, the most common eating disorders, anorexia nervosa and bulimia nervosa, will be discussed in terms of their link to potential self-regulation issues.

2.2.5 Anorexia Nervosa

Anorexia nervosa (AN) is an ED associated with severe restriction of food leading to a significantly low body weight (APA, 2013). Patients with AN also demonstrate fear of gaining weight, or becoming overweight, even though they are typically dangerously underweight, and also demonstrate body disturbances whereby they overestimate their own body size, commonly known as body dysmorphia (Jacquemot & Park, 2020).

Our understanding of the mechanisms that might mediate the development of AN has been furthered by advances in neuroimaging techniques where, for example, structural alterations in the frontal cortical regions of the brain have been observed in AN patients (Frank et al., 2019). Katzman and colleagues (1997) pioneered research into structural changes, demonstrating through magnetic resonance imaging (MRI) that adolescent girls with AN had significantly reduced grey matter and white matter total brain volumes, including reduced volume in the frontal cortex. As outlined earlier, research has shown that the PFC plays a central role in SR, specifically by exerting top-down control over subcortical regions involved in reward (e.g., striatum) and emotion (e.g., amygdala; Kelley et al., 2019). Consequently, SR deficits may be significantly correlated to AN development and maintenance, since reduced frontal cortex volume might in turn reduce SR capacity.

Based on the strength model of self-control (Baumeister et al., 1994), whereby the ability of enact SR strengthens like a muscle the more it is used, research demonstrating SR deficits in AN are contradictory given that SR would need to be consistently engaged to divert from the biological need to consume food to attain the weight loss goal. Consequently, patients with AN should present with increased SR. However, AN is often associated with significant emotional regulation disturbances (e.g. Hatch et al., 2010), suggesting that these deficits may be better explained by an alternative theory of SR such as that of self-efficacy (Bandura, 1997).

2.2.6 Bulimia Nervosa

Bulimia nervosa (BN) is another form of ED which is associated with frequent episodes of binging whereby a large quantity of food is consumed within a discrete period of time, and the person engaging in the binge feels a lack of control over their eating during this episode. This binge is then followed by compensatory behaviour to try and prevent weight gain, commonly self-induced vomiting but other actions also include laxative use, diuretics, and overexercising (APA, 2013).

From a neurocognitive perspective, evidence has demonstrated that adolescents with BN displayed abnormal activation of a number of regions of the PFC of the brain when engaging in the SR control necessary to resolve conflict (Marsh et al., 2009). This suggests some form of functional disturbance within the neural systems of BN patients which restricts their ability to exhibit SR.

Schupak-Neuberg and Nemeroff (1993) explored the cognitive ability of patients with BN, and discovered that the binge/purge behaviour associated with the condition may be utilised as a dysfunctional method of emotion regulation, whereby these behaviours provide a short-term reduction in negative affect. However, it has been suggested that this cycle only serves to reinforce poor SR, as binging only reinforces this emotional disturbance and so leads to greater difficulty in regulating eating impulses (Biberdzic et al., 2021).

Moreover, recent research has demonstrated that interventions designed to target deficits in emotion regulation and impulse control greatly improved emotional control, and reduced binging episodes in BN (Presseller et al., 2022). Similarly, increases in self-efficacy have been associated with greater control during binge eating, and a reduction in purging frequency (Schneider et al., 1987), suggesting that levels of self-efficacy and associated SR play a strong role in with BN.

The fixation on food and body weight associated with both AN and BN is a necessary daily demand of living with type 1 diabetes. The following section will focus on understanding this chronic condition and its daily demands, as well as exploring its associations with EDs and SR.

2.3 Type 1 Diabetes

2.3.1 Overview

Type 1 diabetes (T1D) is an autoimmune condition which results from the destruction of beta cells in the islets of Langerhans within the pancreas, which produce the hormone, insulin (Bluestone et al., 2010; Todd, 2010). The specific cause of T1D is still somewhat unknown, although it is generally considered to be a condition with genetic, environmental, and immunological aspects of development (Atkinson et al., 2014). An individual who develops T1D is therefore unable to produce insulin. Insulin is a one of many vital hormones produced by the human endocrine system, which functions to reduce blood glucose (BG) concentration by allowing glucose to move from the bloodstream into the body's cells, where it can then be used for energy (DiMeglio et al., 2018).

Without sufficient insulin in the body to remove glucose from the blood stream, its concentrations will continue to rise, which in a very short period of time can lead to hyperglycaemia (high BG). An individual with T1D who is experiencing hyperglycaemia can very quickly fall into the potentially fatal state of diabetic ketoacidosis (DKA). DKA is the result of the body breaking down fat as an energy source as the lack of insulin starves cells of their vital energy resource, glucose. DKA helps maintain muscular and tissue functions, but is associated with rapid weight loss (Kitabchi & Wall, 1995). In order to maintain homeostasis, the human body employs many physiological adaptations. One of these is maintaining an acid-

base balance (pH). As fat is broken down, ketones (fatty acid by-products) are released into the bloodstream. A high amount of ketones causes the blood to become acidic (the blood pH is too low). This creates an emergency medical situation that requires immediate attention and treatment. Mortality rates of patients with T1D in DKA vary widely depending on their general health, but evidence suggests that 10-15% of these patients will sadly lose their lives (Krentz & Nattrass, 2003). Currently, the only way of managing T1D is for individuals to manually administer insulin, generally through frequent insulin injections or via an insulin pump which is a small wearable device that delivers short-acting insulin every few minutes in tiny amounts, 24 hours a day. It can also be programmed to deliver short-acting insulin when carbohydrates are consumed, and additional if the need arises to bring high blood glucose levels down. The following section will explore the long-term complications which can arise as a result of prolonged high blood glucose (hyperglycaemia).

2.3.2 Vascular Issues Associated with Hyperglycaemia

Persistent hyperglycaemia over a prolonged period can lead to the development of a number of vascular complications associated with increased morbidity, including (but not limited to) retinopathy, neuropathy, nephropathy, cerebral oedema, and early mortality.

Prolonged hyperglycaemia can cause swelling in the micro blood vessels in the retina of the eye. These microaneurysms indicate diabetic retinopathy and can cause issues with vision. There are four stages of diabetic retinopathy, ranging from mild (where small swellings of the blood vessels in the retina are identified), moderate and severe non-proliferative (where these blood vessels become blocked, eventually causing haemorrhaging), and proliferative (where the growth of new, abnormal, blood vessels is triggered) retinopathy (Yun et al., 2008). By the proliferative stage, vision is severely compromised. While prognosis following

treatment is usually good, treatment can cause adverse effects like blurring of central vision and constriction of the visual field (Lövestam-Adrian et al., 2003). Diabetic retinopathy is associated with significant reductions in both physical and mental quality of life (Davidov et al., 2009).

Extended hyperglycaemia can also result in the development of neuropathy, as increased BG concentrations cause nerve fibre degeneration (Yagihashi et al., 2011) which can lead to significant pain (Feldman et al., 2019). Treatment of diabetic neuropathy is limited and is often restricted to management of the pain through painkillers, tricyclic antidepressants, and short treatments of corticosteroids (Said, 2007). Patients living with this condition report reduced quality of life, and the feeling of burdening those around them (Lewko et al., 2007).

Hyperglycaemia can lead to significant tissue damage in the kidneys (Pourghasem et a., 2015), as the body must purge excess glucose from the bloodstream. This can lead to the development of diabetic nephropathy, which is a significant cause of chronic kidney disease and renal failure (Lim, 2014). While there are some pharmacological treatments such as antihypertensives which can help delay the progression of diabetic nephropathy, there is as yet no single treatment which can halt its development. The condition is associated with a distinct reduction in quality of life, particularly among those receiving haemodialysis (D'Souza et al., 2020).

Another severe complication is cerebral oedema, caused by an increase in extracellular fluid as a result of DKA which results in an increase in cranial pressure. There is currently little diagnostic definition of the condition, as the clinical presentation is somewhat variable, so it often goes undiagnosed until post-mortem (Edge, 2000). It is a potentially life-threatening complication of T1D and is the leading cause of death among children with T1D. While the

risk of developing cerebral oedema in adulthood is minimal (Castellanos et al., 2020), it still remains an area of concern.

Each of these conditions associated with prolonged hyperglycaemia are also associated with increased mortality rates. Individuals with T1D and non-proliferative or proliferative retinopathy have been shown to have higher mortality rates (van Hecke et al., 2005). This risk is echoed in individuals with T1D and autonomic neuropathy (Veglio et al., 2000). Similarly, diabetic nephropathy has been associated with a 2.5-fold increase in mortality in T1D (Groop et al., 2009). Much of this early mortality is thought to be the result of comorbid cardiovascular issues associated with these microvascular complications, which result from prolonged hyperglycaemia (Astrup et al., 2006; Garofolo et al., 2019). It is therefore of the upmost importance to the long-term physical, mental, and emotional wellbeing of an individual with T1D to maintain daily management of their diabetes, to avoid prolonged periods of hyperglycaemia and evade the associated vascular complications. In the following section, the numerous daily demands of living with T1D will be explored.

2.3.3 Daily Management of Type 1 Diabetes

The daily effort and motivation required to effectively manage T1D is extensive. BG must be monitored on a regular basis to ensure that levels are within a safe and ‘desired’ range (these can vary from individual to individual, although official guidelines suggest BG should be maintained between 4 and 9mmol/l; NHS Inform, 2023). Most people with T1D utilise carbohydrate counting to allow them to have fewer restrictions in their diet, and guidelines suggest that shortly following diagnosis people with T1D should receive training for this, which in the UK is usually done by attending a Dose Adjustment For Normal Eating (DAFNE) course. Following this training, people with T1D have the tools to calculate the amount of

carbohydrates they are consuming each time they eat. Then, based on their carbohydrate to insulin ratio for that time of day or month, determined over time through trial and error, an appropriate dose of insulin can be administered. These ratios, however, can change depending on insulin resistance throughout the day, and for women are especially affected by hormonal variability throughout their menstrual cycle. This is particularly difficult for both adolescent girls and women going through menopause, as there is greater fluctuation of a number of hormones during these periods which impact insulin sensitivity and glucose metabolisation (Amiel et al., 1986; Kelsey & Zeitler, 2016; Polotsky & Polotsky, 2010), which is why these populations have been omitted from the current research. When formulating this insulin dosage, there are also further considerations such as the type of carbohydrates being consumed (i.e. refined sugar, starch, containing dairy etc), as this can have an impact on the rate at which the carbohydrate is absorbed, and thus how the insulin dose should be administered (a pre-bolus to avoid highs associated with refined sugar; split bolus for starchy/dairy foods). This mental calculation must be undertaken multiple times every day, at each point a person with T1D decides to consume any food or drink containing carbohydrates.

Moreover, there are numerous additional factors which must also be considered by people with T1D throughout the day. Level of exercise, for example, must be considered with regard to BG levels and insulin dosages, as greater activity means higher energy expenditure and therefore a greater demand for glucose. As exercise normally leads to a reduction in BG (Colberg et al., 2013) an individual may wish to reduce their insulin dose or consume additional carbohydrates. However, higher intensity exercise is linked to an increase in the stress hormone cortisol which can cause BG levels to rise (Adams, 2013) meaning the type and intensity of exercise must also be considered. If BG levels are too high during exercise (general guidelines suggest 13.9 mmol/l or greater) then the body does not have sufficient insulin to extract the extra energy needed while exercising, which can lead to the production of ketones as the body

instead utilises fat as its energy source (Mayo Clinic, 2022). There is also a large variability in individual responses to exercise (Yardley et al., 2018), so again trial and error must be employed by a person with T1D while attempting to maintain 'optimum' BG range.

In addition to the potential increase in cortisol levels due to strenuous exercise, there are other hormonal factors that impact BG levels. For example, a stressful and anxiety-provoking event such as a job interview or presentation activates the sympathetic nervous system resulting in a release of adrenaline from the adrenal glands, It will also trigger the hypothalamic-pituitary-adrenal (HPA) axis to release cortisol. Activation of the HPA axis and concomitant increase in stress hormones adrenaline and cortisol causes an increase in BG preparing the body for the 'fight or flight' response (Foss & Dyrstad, 2011). People with T1D must therefore pre-empt this by administering additional insulin, to avoid a hyperglycaemic event.

2.3.4 Type 1 Diabetes and Mental Health

The constant pressures of managing T1D can take their toll, and a number of mental health conditions have been demonstrated as more prominent among people with T1D, including anxiety, depression, and certain eating disorders (EDs). Indeed, T1D and an associated ED is now commonly known as type 1 diabetes and disordered eating (T1DE).

Prevalence rates of anxiety among people with T1D have been demonstrated as significantly greater than among the general population. In a study of adolescents and young adults with T1D, Bernstein and colleagues (2013) found that one in five screened positive for anxiety. These results were echoed in a recent review, which concluded that anxiety was more prevalent among children and young people with T1D compared to controls (Rechenberg et al., 2017). This anxiety was also associated with comorbid depression, difficulties with self-

management and coping strategies, and increased HbA1c, which is a measure of average blood glucose levels for the last two to three months. Research has suggested that women with T1D have an increased prevalence of anxiety compared to controls, which in turn was associated with increased HbA1c (Shaban et al., 2006).

The literature surrounding depression in T1D is somewhat more conflicted. In a review of the literature comparing prevalence of depression in adults with T1D versus controls, Barnard and colleagues (2006) found that 12% of adults with T1D presented with clinical depression, compared to just 3.2% of control participants, suggesting that those with T1D were significantly more likely to present with comorbid depression. The authors did recognise that their results should be viewed with caution given that only a few studies included in their review used diagnostic interviews to assess depression, while a number used self-assessment questionnaires which tend to overestimate its prevalence. However, it still demonstrated the significance that T1D can have on overall mood. A recent study by Fisher and colleagues (2015) echoed the caution expressed by Barnard et al. (2006) of using questionnaires, as they demonstrated questionnaires such as the Patient Health Questionnaire led to high rates of false-positives results of depression, and suggested that depression in adults with T1D likely represents significant emotional distress associated with the daily demands of managing the chronic illness, rather than depression *per se*. A recent systematic review, however, demonstrated that depression was higher in people with T1D compared to controls, and that estimated prevalence did not differ significantly depending on the method of assessment (Farooqi et al., 2022). Regardless, these studies all concur that the emotional toll of T1D, whether classified as clinical depression or not, significantly impacts diabetes management and is associated with poorer glycaemic control, and a greater risk of future vascular complications (Farooqi et al., 2022). It ought to be noted, however, that depression has been associated with an increased risk of severe hypoglycaemia (Katon et al., 2013). Frequent episodes of

hypoglycaemia can skew HbA1c measures by lowering the average, meaning that HbA1c alone should not be relied upon as an indicator of psychological difficulties in T1D.

Moreover, comorbid depression and T1D has been associated with higher mortality, particularly among women whose rates of developing depression increase nine-fold compared to the general population (NHS IC, 2008). This could, in part, be due to lack of treatment adherence associated with comorbidity of T1D and depression, which causes the subsequent increase to HbA1c (Gonzalez et al., 2008; van Tilburg et al., 2001). As has already been explored, this increase can lead to a number of vascular complications which can lead to early mortality. It could also be linked to research indicating that individuals with T1D are at greater risk of suicide (Pompili et al., 2014), with some studies indicating that suicide attempts in people with T1D are three to four times more likely than in the general population (Roy et al., 2010). Roy et al. (2010) also demonstrated that those with T1D who attempted suicide were more likely to be female, suffer with depression, experienced childhood trauma, and were more likely to abuse drugs and alcohol. In terms of diabetes management, it is interesting to note here that substance misuse has been associated with impairments in self- regulation, as individuals are unable to exert sufficient cognitive control make healthy choices (Schmeichel & Baumeister, 2004) and turn to substances as a mechanism of escape from previous trauma (Brady et al., 2004).

2.3.5 Type 1 Diabetes, Weight Preoccupation, and Food

Prior to T1D diagnosis, there is often significant weight loss as the body is unable to retrieve the energy it needs from glucose and must therefore use fat instead. There is also significant water loss and dehydration which causes greater weight loss, given that higher concentrations of glucose in the blood stream leads to the movement of water from the body's cells via osmotic

pressure; most of which is lost through the urine. This weight loss may be associated with social praise (Tate et al., 2021). Upon diagnosis, individuals with T1D will often receive isotonic fluids to combat the dehydration (Castellanos et al., 2020), and will therefore see a rapid change in body shape over the first few hours following hospitalisation. This is particularly seen among individuals who are in DKA at diagnosis, as fluid retention is common once treatment has begun (Goebel-Fabbri, 2009). This can lead to patients feeling bloated and uncomfortable, and as such may enhance difficulties with body image. Furthermore, once an insulin regime is initiated, individuals with T1D will begin to rebuild their depleted fat stores, meaning that there is often a period of weight gain following diagnosis. This weight gain will often result in an increase in body weight compared to prior to diagnosis (Hall et al., 2021), and particularly in individuals receiving intensive insulin therapy, this weight gain can even result in obesity (Purnell et al., 2017). A combination of body praise following weight loss prior to diagnosis, and significant weight gain as a result of diagnosis and treatment, can lead individuals with T1D to develop an unhealthy relationship with their body, and to develop an association between insulin and weight gain (Meltzer et al., 2001).

Weight preoccupation is then further enhanced during outpatient diabetes clinics, who as part of the 8 care processes for diabetes (National Institute for Health and Care Excellence [NICE], 2015) take measurements of weight and height to calculate a patient's body mass index (BMI). Many healthcare professionals lack an awareness of the sensitivity that this weight preoccupation requires, and promoting an understanding of the factors which may lead to the development of EDs in T1D among these professionals may help prevent their development (Daneman et al., 1998). Missed medical appointments have been associated with an increased risk of EDs in T1D, and among those who miss appointments BMI has been shown to be higher (Pinhas-Hamiel & Levy-Shraga, 2013). This could suggest that the weight preoccupation caused by diabetes clinics may cause T1Ds who are suffering with negative body associations

to avoid vital clinic appointments, which may expose these individuals to a greater risk of harm (Hanna, 2012).

As previously discussed, the attention that living with T1D places on food is extensive. Following completion of the DAFNE course, individuals with T1D should gain the knowledge of carbohydrate counting and appropriate insulin adjustments to allow them relative freedom with regards to the foods they consume, through intensive insulin therapy. While research has shown that quality of life measures significantly improved in patients following the training (DAFNE Study Group, 2002; Singh & Bradley, 2006), even a year after participation it does cause individuals with T1D to place significant focus on food (McIntyre et al., 2010). The detail required to plan and precisely portion food and monitor carbohydrate intake has been suggested to make people with T1D inherently more prone to suffering with food-related issues (Goebel-Fabbri, 2009; Hanlan et al., 2013). This necessary focus on food may also lead to issues in SR, as cognitive resources are diverted to preoccupation with food (Beedie and Lane, 2012). Treatment of disordered eating behaviours among those with T1D is also significantly more difficult. In standard ED treatments, when devising a treatment plan an emphasis would be placed on reducing or eliminating thoughts and fixations around food. For individuals with T1D, however, this is simply not possible if glycaemic control is also to be maintained. Type 1 diabetes appears to be a risk factor for the development of disturbed eating behaviour (T1DE; Mannucci et al., 2005) and one specific to individuals with T1D is insulin omission which will be discussed in the next section.

2.3.6 Insulin Omission

Insulin omission is a disordered eating behaviour unique to individuals with T1D, whereby individuals intentionally omit or reduce insulin doses in order to reduce the metabolism of food

consumed. As noted previously, without sufficient insulin concentrations to manage the intake of carbohydrates, BG levels rise sharply and the body is forced to utilise fat stores for energy which can lead to serious consequences. Inducing hyperglycaemia can quickly cause an individual to fall into DKA which has a high mortality rate, and the long-term vascular consequences of prolonged hyperglycaemia have been highlighted. Although not currently recognised within the DSM-V as a distinct ED in its own right, insulin omission is classified as a purging behaviour given that the body must 'purge' excess glucose from the blood stream through the urine, known as glycosuria (Birk & Spencer, 1989). Understanding and treating insulin omission is therefore critical to ensure the health and wellbeing of individuals with T1D.

The most recognised function of the behaviour is insulin omission as a method of weight loss (IO). Commonly coined by the media as 'diabulimia', IO forces the body into a state of hyperglycaemia where it must utilise fat stores for energy. As mentioned, this can lead to highly rapid weight loss, and as such IO can be abused as a disordered method of weight loss. While IO is the focus of this thesis, it ought to be noted that intentional insulin omission may also serve other functions, such as a method of self-injury, or due to fear of hypoglycaemia (Nixon et al., 2015; Stotland, 2006).

2.3.7 Insulin Omission and Type 1 Diabetes with Disordered Eating

With the intense focus on food, weight and blood glucose levels, plus the many disruptions that occur in a person's metabolic system, T1D is a high-risk factor for in the development of T1D with disordered eating (T1DE; Mannucci et al., 2005). T1DE is an umbrella term for people with T1D with disordered eating or pathological weight control behaviours, including anorexia nervosa (AN), bulimia nervosa (BN), and IO. Similar to the literature surrounding T1D and

depression, there is some dispute among researchers regarding prevalence rates of T1DE and whether disordered eating and EDs are more common among those with T1D than the general population. Estimates of the prevalence rates of T1DE among individuals with T1D range from 10-49% (Colton et al, 2004; Jones et al., 2000).One study of adolescent girls (aged 14-18 years) found that a significantly greater proportion of those with T1D demonstrated disordered eating behaviours (16.9%) compared to age-matched controls (2.2%), as measured by the Eating Disorder Inventory (EDI; Engström et al., 1999). However, Keane and colleagues (2018) found no difference in disordered eating behaviours among young adults with T1D compared to controls when using the Eating Disorder Examination Questionnaire (EDE-Q; Fairburn & Beglin, 1994), which is a questionnaire derived from and scored from an interview schedule of the same name, the Eating Disorder Examination (EDE; Fairburn & Cooper, 1993). A meta-analysis including 8 studies found that the prevalence of AN was no different between those with T1D and controls, although rates of BN were significantly greater among T1D (Mannucci et al., 2005).

As mentioned earlier, discrepancies in prevalence rates could be due to different methodological approaches researchers have taken to identify the presence of T1DE. Interviews like the EDE may underestimate prevalence as participants may consider their disordered behaviours to be socially undesirable, meaning they are therefore unwilling to admit them to an interviewer (Bergen & Labonté, 2020). Moreover, Powers et al. (2013) identified that T1D may affect responses to traditional questionnaires, most notably the EDE-Q where 50% of answers to individual questions could be influenced by the food choices and dietary restraint necessary in T1D. Additionally, generic questionnaires such as the EDI and Eating Attitudes Test (EAT-26; Garner et al., 1982) may also lack sensitivity to assess disordered behaviours in individuals with T1D, as these questionnaires fail to measure behaviours such as carbohydrate avoidance or IO. This may mean that those struggling with T1DE or IO, if

assessed using generic ED questionnaires may risk going undiagnosed for a longer period of time and greater consequences may ensue.

More recent research has utilised a diabetes-specific measure of disordered eating, called the Diabetes Eating Problem Survey-Revised (DEPS-R; Markowitz et al., 2010) to assess T1DE, which includes within its factor structure, *Maintaining High BG to Lose Weight* to assess for IO. One such study found that 27% of women, as well as 18% of men, with T1D had positive scores on the DEPS-R indicating a need for further evaluation of T1DE (Doyle et al., 2017). Ryman and colleagues (2019), however, found that although the DEPS-R was a useful tool in identifying adolescents with T1D at risk of developing T1DE, its ability to identify individuals meeting the diagnostic criteria for an ED was low. However, this could be due to the lack of diagnostic guidelines within the DSM-V relating to T1DE and IO.

Among the first to explore the prevalence of T1DE and IO in individuals with T1D were Fairburn and colleagues (1991). In a study comparing young women with T1D and age-matched controls, they found that disordered eating behaviours were common among both cohorts, meaning T1D did not increase the prevalence of eating disorder pathology when assessed using the EDE (Fairburn & Cooper, 1993). Adaptations were made to the original questionnaire to distinguish between condition motivated behaviours and those attributable to T1DE when assessing T1D participants in this study. Questions regarding insulin misuse and omission were also added, however no validity testing of this amended questionnaire was completed before the study meaning the results must be interpreted with caution. Regardless, the results were among the first to demonstrate the proportion of women with T1D who utilised IO, with 37% of participants reporting underusing or omitting their insulin as a method of influencing their weight. Another important finding of this seminal study was that IO was not restricted to those who scored highly on disturbed eating behaviours on the traditional questionnaire, indicating that some participants reported engaging in IO without presenting

with any further disturbed eating behaviours. This study was therefore one of the first to suggest that, while incidence rates of EDs may not necessarily be higher among those with T1D, the methods of weight loss that those with T1DE engage in often involve IO.

Peveler and colleagues (1992) conducted a methodologically similar study among adolescent girls with T1D, utilising the same amended EDE-Q to assess diabetes-specific eating behaviours. As with the Fairburn et al. (1991) study, they found no evidence that EDs were more common among girls with T1D compared to controls. BMI results did demonstrate, however, that individuals with T1D were significantly heavier, and these girls dieted more intensely to control their weight and shape. Their results also demonstrated that 15% of girls with T1D admitted to engaging in IO. This difference in IO between adolescents and adults with T1DE (15% and 37%, respectively) may suggest that it is a behaviour which individuals become more susceptible to over time. However, research assessing IO prevalence across the lifespan varies, as a longitudinal study found that at baseline five out of 76 adolescents assessed admitted to IO, butat follow-up (7-11 years later) these five no longer reported IO, but IO was reported in five different women (Bryden et al., 1999). This demonstrates the complexity of IO as a behaviour and suggests its differences to other EDs like AN and BN, which tend to be more common in adolescence and reduce during adulthood (Kotler et al., 2001).

Rates of IO vary widely within the research, although some have identified the behaviour in as many as 60% of study participants (Deiana et al., 2016). Similar to other EDs, T1DE and IO appear to be far more prevalent among women than men (Falcão & Francisco, 2017). Understanding the motivations of people with T1D who engage in IO is essential if future interventions are to be developed. Falcão and Francisco (2017) looked to do this in a cohort of young adults with T1D. Using open-ended questions on a newly devised self-report questionnaire, they sought to explore perceptions towards eating, body image, and weight, as

well as examining participant rationale of engaging in IO and their awareness of the consequences. On this questionnaire, participants provided some stark admissions:

> "When I start to do the right control, measure, use the correct dosage, I get too fat (…) I start to eat more and not take insulin, I have long periods without [insulin] to get into ketosis [ketoacidosis]. (24-year-old woman, office manager)"

> "The most I can go is a week with nothing [insulin]… Now I've been months without using the fast [insulin]… I lost 10 kg. (24-year-old woman, office manager)"

> "Because it was a simple way to lose weight while eating what you wanted or without much exercise. (19-year-old woman, student)"

From this, a number of conclusions can be drawn which can help understand the nature of IO. The first quote highlights that individuals with T1D can associate the administration of insulin with weight gain, and therefore see the omission or reduction of insulin as a simple reversal technique to encourage subsequent weight loss. The second quote calls attention to the severity with which IO can present, and demonstrates the extent to which some individuals with T1DE will go to achieve weight loss. However, going a week without any insulin administration is incredibly concerning, particularly as DKA can occur in as little as 24-hours (NHS, 2023), and is fatal in 5-10% of cases (Krentz & Nattrass, 2004). The final quote illustrates the participant's rationale for engaging in IO, and suggests that this individual lacks the necessary motivation

or behavioural monitoring to attain weight loss through healthy methods. This could therefore suggest a self-regulation (SR) deficit in individuals with IO, as they lack the capacity necessary to enact SR behaviours.

The following section will explore the current research examining the relationship between T1D and SR, and the potential links between SR deficits and engagement in IO.

2.3.8 Type 1 Diabetes and Self-Regulation

Lansing and Berg (2014) suggested that SR is the core foundation of managing the individual and interpersonal processes involved in chronic illness self-management, and adolescents who demonstrate deficits in SR struggle to effectively engage with managing their condition. Based on the theory of resource depletion (Baumeister et al., 1994; 1996; 2018) explored earlier, the daily demands of living with T1D which require significant SR effort have the potential to leave individuals in a chronically depleted state, increasing the risk of subsequent failures in SR which in turn will negatively affect T1D management. T1D is also associated with feelings of social isolation (Prell et al., 2023), which could reduce motivation in management based on the need-to-belong theory explored earlier (Baumeister, 2012), and be a further explanation to subsequent SR failures (Baumeister et al., 2007).

A body of literature has assessed the relationship between SR and T1D. McCraty et al. (2000) demonstrated that patients with diabetes experienced a significant reduction in negative emotions, and reduced sensitivity to life stressors, after following an emotional SR program designed to improve quality of life. Butner and colleagues (2018) found that failures in daily condition management of T1D among adolescents were associated with lower levels of SR, and suggested that adherence to the principles of T1D management may be a key driver to increasing aspects of SR like self-efficacy as is consistent with Social Cognitive Theory

(Bandura, 1997). Grylli and colleagues (2010) were among the first to evidence that adolescent girls with T1DE also display deficits in SR by utilising the EDE and The Narcissism Inventory-90 (NI-90; Deneke & Hilgenstock, 1989). However, the NI-90 assesses dimensions of SR concerned with self-identity, as opposed to measures of executive function skills like planning and organising which are captured more adequately by questionnaires like the Short Self-Regulation Questionnaire (Carey et al., 2004). Using the Behaviour Rating Inventory of Executive Function (BRIEF) 19% of adolescents with moderate to high T1DE (assessed through the DEPS-R), also reported executive function impairments, indicative of SR deficits (Cecilia-Costa et al., 2021). This supports the findings of Broadley et al. (2018) who found the same trend of executive function impairments using hierarchical regression. It has been suggested that facets of SR act as risk and protective factors in the management of T1D in adolescents, and that SR targeted interventions and its use in daily life may be useful (Wiebe et al., 2018). However, to the best of the author's knowledge there is currently no research which has explored the role of SR in relation to IO. Neurocognitive research has indicated that individuals with T1D may have lower baseline cognitive function. For example, a meta-analysis found that performance was significantly lower among T1Ds on a range of EF tasks including inhibition, working memory, and set-shifting (i.e. the ability to move between different tasks; Broadley et al., 2017). This was also shown by Ryan et al. (2016), who also suggested that chronically elevated BG can increase the risk of cognitive dysfunction. This may suggest a vicious downward spiral of IO whereby an initial SR deficit leads to the engagement of IO, which in turn results in a greater SR deficit.

Furthermore, in terms of cognitive effort, IO is a far less taxing behaviour for individuals with T1D to engage in than maintaining a new dietary pattern or frequently exercising. This could suggest that those who engage in IO lack SR capacity which prohibits them from developing the motivations and behaviours necessary to lose weight in a healthy

manner. Consequently, those who wish to lose weight turn to IO as the only option they have the cognitive capacity for. This theory would also provide a basis for the difference in reported prevalence of IO between the adolescents in Peveler and colleagues' (1992) study, and the adults in the study by Fairburn and colleagues (1991), whereby adults with T1D are more susceptible to IO because they have often lived with the condition for a longer period of time. Over time there is greater chronic depletion to SR stores, thus reducing the capacity of those with T1D to enact healthy methods of weight loss.

The findings on chronic ego depletion by Wang and colleagues (2015) support this, whereby the process of continually enacting SR effort causes a chronic reduction in subsequent SR behaviour. Consequently, depleted SR among those with T1D may lead to less adherence to goals, and therefore greater difficulties in daily management of the condition. Moreover, given the link between SR deficits and certain EDs, and the prevalence of T1DE and IO in T1D, it is hypothesised that those who engage in T1DE and IO will also present with lower scores on measures of SR.

Modern technological advancements in T1D must also be considered in terms of SR demand. To maintain optimum control of their condition, people with T1D must enact high levels of self-monitoring and SR multiple times a day, every day, as previously described. BG levels have to be observed, and adjusted if necessary through additional insulin and/or a glucose supplement throughout the day. In previous years this necessitated finger pricking to draw blood, which could be assessed by an electronic monitor to give a measure of BG concentration. Thanks to advancements in technology and changes to the NICE guidelines, most people with T1D in the UK ought to now have access to flash glucose monitoring, or continuous glucose monitoring devices (CGM). Such devices rely on the measurement of glucose concentrations in the interstitial fluids, which offers numerous advantages considering that subcutaneous tissue is easily accessible for sensor implantation. The minimal invasiveness of CGM devices

compared to traditional intravenous or capillary glucose monitoring means that glucose can be monitored in real-time for longer periods and allows for a more comprehensive glycaemic assessment. This technology does however mean that patients with T1D are more exposed to their BG and therefore forced to manage it more frequently throughout the day. The ease of measuring BG through this modern technology offers greater opportunity for better control (Ramchandani et al., 2012), but has been reported to cause increased general anxiety and depressive symptoms among young people (Markowitz et al., 2012). It could be argued that this modern technology may result in greater SR demand as more frequent assessment of BG also means potentially more frequent need for additional measures to be taken to optimize BG level, which in turn could arguably cause a greater depletion of SR stores. Whether there are differences in SR between people utilising different methods of BG management is beyond the scope of the current thesis, but the potential impact that flash monitoring and CGM technology may have needs to be considered.

2.4 Thesis Aims

The purpose of the current thesis was to extend the current literature and gain a better understanding of the relationship between SR and T1D in adult women (to control for issues surrounding extraneous hormonal fluctuations in adolescence and menopause as previously mentioned). Further, we wished to explore whether failures in SR were linked to difficulties in managing T1D, and whether SR deficits were associated with increased incidences of T1DE and IO. Moreover, a greater understanding as which the aspects of managing T1D lead to disruptions in SR was also sought, as given the extensive daily requirements of T1D it was hoped to isolate particular facets which have the greatest demands on SR.

Chapter 3

Paper 1:

Self-Regulation as an Early Predictor of Eating Disorder Development in Women

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3.1 Abstract

Objective: Self-regulation (SR) is a capacity which allows us to manage behaviours and emotions to attain long-term goals. Deficits in SR capacity have been demonstrated among people with eating disorders, but there is currently little research assessing this capacity in the general population. This study aimed to examine the roles of SR on eating attitudes and body satisfaction in a non-clinical sample.

Method: 223 UK females completed the Short Self-Regulation Questionnaire (SSRQ), Eating Attitudes Test (EAT-26), and Body Shape Questionnaire (BSQ) in an online study.

Results: SSRQ was a significant predictor of scores on the EAT-26 Total, the EAT-26 *Bulimia and Food Preoccupation* subscale, and the BSQ. This indicated that as SR capacity decreased, incidences of disordered eating and body dissatisfaction increased.

Conclusions: Reduced SR capacity could be an early indicator of susceptibility to negative body image, disordered eating behaviours, and eating disorders in women. Preventative or early intervention treatments should consider including strategies aimed at boosting SR.

Keywords: Self-regulation, disordered eating, bulimia nervosa, eating disorder, body image

3.2 Introduction

Eating is one of life's most fundamental behaviours. Ensuring the body has adequate nutrition to perform all of its complex biological processes is innate. This could explain why there is limited research into the potential biological or cognitive mechanisms associated with eating disorders, which drive behaviours like severe food restriction (Frank et al., 2019). There is currently no evidence to suggest that other species intentionally restrict or purge their food intake, both of which are diagnostic criteria across different eating disorders (EDs). The presence of eating disturbances for weight loss, and dissatisfaction with body shape, therefore, appear to be specific to humans. This would suggest the involvement of higher cognitive processes unique to the human brain, such as those within the prefrontal cortex (PFC). If the development of disordered eating behaviours is linked to a deficit in one of these higher cognitive processes, then the ability to identify this deficit early within the general population could help identify those at risk of developing EDs.

One cognitive process which has demonstrated links to human eating behaviour is self-regulation (SR). SR is defined as the ability to manage one's emotions and behaviours to attain long-term goals (Nigg, 2017). It is thought to develop during childhood, when a number of executive functioning skills including attention, memory, and language merge together through white matter connectivity in the PFC (Fiske & Holmboe, 2019). The capacity to self-regulate continues to develop and increase through adolescence and into adulthood, and comes into effect when subconscious regulatory processes fail to accomplish tasks and goals (Herman & Polivy, 2011). Having capacity to self-regulate therefore means being able to actively monitor one's emotions and alter one's behaviours to remain in line with desired outcomes.

Research has demonstrated that SR can affect our eating behaviours. In a review of the literature, Johnson and colleagues (2012) highlighted that dietary restraint is necessary to maintain calorie restriction, and that SR is a key factor in successful weight maintenance.

Moreover, deficits in SR have been associated with negative nutrition attitudes (Balani et al., 2019). This implicates the important role that SR has on dieting behaviour and attitudes towards eating, as this capacity must exceed the temptations around a individual. As Baumeister and Heatherton (1996) describe, SR failures occur when a person experiences an occasion where the costs outweigh the benefits. An initial SR failure which leads to a person eating a single biscuit, however, can result in a bingeing episode due to lapse-activated misregulation (Herman & Mack, 1975). Without sufficient SR, maintaining a change in dietary regime is consequently almost impossible. Moreover, research has suggested that body image plays a significant role in driving eating SR (Carraça et al., 2011) Therefore, if dietary changes are driven by negative body image and low self-esteem, this can lead to the development of disordered eating behaviours and subsequent EDs (Smink et al., 2018; Vartanian & Dey, 2013).

An ED is a serious mental health condition in which a patient uses control of food as a method of emotional control (NHS, 2021). While present across genders, women are disproportionally more likely to develop an ED than men (Sepulveda et al., 2008). Distinct behavioural criteria are required to enable the diagnosis of different eating disorders. For instance, anorexia nervosa (AN) symptoms are categorised by the DSM-V (American Psychiatric Association, 2013) as energy intake restriction leading to significantly low weight, with high disturbances in body shape and fear of gaining weight. Bulimia nervosa (BN), meanwhile, is characterised by recurring episodes of binges (the intake of large quantities of food within a limited amount of time) followed by subsequent compensatory behaviours such as vomiting or misuse of laxatives (American Psychiatric Association, 2013). In patients with BN, body shape and weight concerns excessively impact self-perception and self-evaluation.

Goodsitt (1983) was among the first to identify the role that SR plays in EDs, describing them as “a disorder of deficient [SR]”. Subsequent research identified specific SR impairments in patients with anorexia nervosa, compared to controls, with lower SR ability associated with

greater incidences of negative eating attitudes and body dissatisfaction. (Karwautz et al., 2001; Beadle et al., 2013).

Evidence of the role of SR in BN is somewhat limited, although given that in dieting bingeing episodes have been associated with SR failures (Herman & Mack, 1975), it is not surprising that individuals with BN have been shown to demonstrate significant disturbances in emotion regulation, a major component of SR (Schupak-Neuberg & Nemeroff, 1992). More specifically, bingeing episodes were associated with an effort to escape self-awareness, while the subsequent purging episode served to try and mitigate negative affect. These findings have been further evidenced by Lavender and colleagues (2015), who in a review of the literature demonstrated broad regulatory deficits within the BN population. A body of evidence supporting a relationship between SR deficits and BN is now also coming from neurological research. Marsh and colleagues (2009) demonstrated that women with BN had activation failures in the appropriate neural circuits of the PFC, indicating that the neural processes of SR were impaired. Furthermore, fMRI research found evidence of abnormal maturation of fronto-striatal circuits in patients with BN, suggesting developmental deficits in SR capacity which might increase susceptibility to developing an ED (Berner & Marsh, 2014).

While these deficits have been found among clinical ED populations, little attention has been given to the relationship between SR, eating attitudes, and body satisfaction in the general population. Cook-Cottone (2016) acknowledged that since SR deficits have been identified as significant risk factors in ED development, prevention must focus on enhancing SR capacity and improving self-body relationships. Deficits in SR could also be used as a marker for greater susceptibility to ED development. The purpose of the present study was therefore to gain a quantitative insight into the relationships between SR, eating attitudes, and body satisfaction in a non-clinical population. We predicted that reduced SR may be associated with greater disturbances in eating attitudes, and lower body satisfaction, respectively.

3.3. Methods

3.3.1 Participants

224 participants completed the study, based on a power calculation of $\alpha = .05$, $\beta = .2$, and $r = .2$ which suggested a minimum sample size of 194 participants. Inclusion criteria required participants to be female, aged 18-50 and UK residents. Data from one participant was excluded because they incorrectly entered their age, giving a final sample of 223 females aged between 18 and 50 ($M = 29.30$, $SD = 9.39$). Participants were recruited through the online participant recruitment website Prolific.co, and the SONA Research Management System. This study received ethics approval on 25/08/2020.

3.3.2 Materials

Short Self-Regulation Questionnaire (SSRQ; Carey et al., 2004)

This 31-item questionnaire is adapted from the original 62-item Self-Regulation Questionnaire (SRQ; Brown et al., 1999) designed as measure of self-reported self-regulation. The SSRQ utilizes a single-factor structure and scores on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), meaning participants can score between 31 and 155. An example of the questions included in the SSRQ includes "*I usually keep track of my progress towards my goals*". Its internal consistency is high ($\alpha = .92$; Neal & Carey, 2005), and it is highly correlated with the original SRQ ($r = .96$; Carey et al., 2004).

Eating Attitudes Test – 26 (EAT-26; Garner et al., 1982)

This 26-item questionnaire is a widely used standardized measure of assessing eating disorder characteristics. It uses a 6-point Likert scale ranging from *always* to *never*. The questionnaire items form three subscales: *Dieting*, *Bulimia and Food Preoccupation*, and *Oral Control*.

Dieting contains 13 questions (e.g., *Am terrified about being overweight*). *Bulimia and Food Preoccupation* contains 6 questions (e.g., *Find myself preoccupied with food*). *Oral Control* contains 7 questions (e.g., *Avoid eating when I'm hungry*). Scoring is coded between 0 and 3, so participants can score a maximum of 78, although a score of 20 or greater highlights cause for concern with regard to eating behaviour (Garner et al., 1982). The internal consistency of the EAT-26 is high (α = .90; Garner et al., 1982), and test-retest reliability ranges between .84 and .89 (Banasiak et al., 2001).

Body Shape Questionnaire (BSQ; Cooper et al., 1987)

This 34-item questionnaire is designed to measure body shape concerns. Its 6-point Likert scale ranges from 1 (*never*) to 6 (*always*). An example question includes "*Have you been so worried about your shape that you have been feeling you ought to diet?".* A score under 80 indicates no concern with body shape, between 81 and 110 indicates mild concern, between 111-140 indicates moderate concern, and above 140 indicates a marked concern with body shape (Taylor, 1987). The questionnaire has strong internal consistency across different countries (α = .93 to .98; da Silva et al., 2014; Warren et al., 2008) and displays adequate temporal stability reliability after 1 month (*r* = .81 to .95; Rousseau et al., 2005; Akdemir et al., 2012).

3.3.3 Procedure

Participants completed the study through Qualtrics via an internet enabled electronic device. After providing informed consent, and following some demographic questions, participants completed the three questionnaires in the following order: SSRQ, EAT-26, then BSQ. Forced responses for each question were in place to ensure none were accidentally missed, however an additional response of "prefer not to say" was included for every question should a participant wish to decline an answer. Any response to this end was coded as missing data.

Each questionnaire was presented on a separate page. Participants were asked if they were happy to continue to the next questionnaire at the end of each page. No participants indicated that they wished to leave the study early. Participants who completed the study through Prolific were compensated £2.88 for their time, in accordance with their fair rates of pay. Participants who completed the study through SONA received credit compensation. Participants were debriefed at the end of the study, and were guided to various helpful links (MIND, Beat, CALM) should they have experienced any emotional discomfort during the study.

3.3.4 Design

Pearson's correlation analyses were first conducted to gain an initial insight into the relationship between self-regulatory capacity (SSRQ), eating behaviours (EAT-26), and body satisfaction (BSQ). A series of linear regressions were then conducted to examine the impact of SSRQ on EAT-26 and BSQ scores in a female population. All data was analysed using SSPS version 27. Prior to analysis, data was initially assessed for normality through Q-Q plots, boxplots, and collinearity statistics.

3.4 Results

Scores on the EAT-26 and BSQ questionnaires were categorised to examine eating attitudes and levels of body satisfaction among participants. Of the 223 participants, a total of 32 (14.3%) had scores (≥ 20) on the EAT-26 questionnaire indicating significant concern about eating. Furthermore, a total of 84 (37.7%) participants indicated moderate or marked concern for their body shape, respectively. A full breakdown of categorisation on the EAT-26 and BSQ questionnaires can be found in Table 1.

Pearson's correlation analysis revealed significant negative relationships between SSRQ scores and the EAT-26 *Bulimia and Food Preoccupation* subscale ($p < .01$), as well as between the SSRQ and EAT-26 Total ($p < .05$). SSRQ was also significantly negatively related to the BSQ ($p < .01$). See Table 2 for full correlation analysis.

Linear regression analysis revealed that SSRQ was a significant predictor in the EAT-26 Total regression model, $F(1, 221) = 3.97$, $p = .048$, accounting for 1.8% of variance. This meant that as SR scores reduced, scores on the disordered eating measure increased. Among the EAT-26 subscales, significance was only found for SSRQ on the *Bulimia and Food Preoccupation*, $F(1, 221) = 12.69$, $p < .001$, explaining 5.4% of variance. SSRQ was not a significant predictor on the *Dieting* or *Oral Control* subscales ($p > .05$). Significance was also found for SSRQ on the BSQ model, $F(1, 221) = 9.85$, $p = .002$, accounting for 4.3% of variance. A full breakdown of regression statistics can be found in Table 3.

3.5 Discussion

This study was interested in evaluating the extent to which SR plays a role in the development of disordered eating behaviours and body dissatisfaction among women in a non-clinical population. We hypothesised that lower SR capacity would be associated with greater reports of disordered eating behaviours, and greater body dissatisfaction, respectively. Our results provide some tentative evidence in support of these hypotheses. Lower SSRQ scores significantly predicted higher scores on the EAT-26, indicating that those with reduced SR capacity were more likely to engage in disordered eating behaviours. This supports previous findings (Goodsitt, 1983), that disordered eating behaviours are linked to deficient levels of SR. It also provides evidence to the argument that EDs may develop as a as a result of failed dieting attempts due to lack of SR. Insufficient SR and subsequent inability to control eating

impulses leads to weight gain (Johnson et al., 2012). When also associated with a negative body image, as often seen in this study with 37.7% of participants indicating concern for their body shape, this can cause unhealthy behaviours to develop as a coping mechanism.

Lower SSRQ scores also were associated with higher scores on the EAT-26 *Bulimia and Food Preoccupation* subscale, indicating that reduced SR appears to be associated with higher incidences of bingeing and purging behaviours, as well as a reduced sense of control over the food that is consumed. This supports previous findings indicating the role of SR in the development of BN (Schupak-Neuberg & Nemeroff, 1992; Lavender et al., 2015). In light of earlier observations that individuals with BN demonstrate activation failures in areas of the PFC which determine SR capacity (Marsh et al., 2009) this could indicate that prior to or in the absence of a clinical diagnosis, diminished SR capacity might increase susceptibility of developing BN (Berner & Marsh, 2014). If that was the case then identification of SR impairments might allow early intervention designed to improve SR capacity and help prevent development of BN.

Lower SSRQ scores were also found to be a predictor of increased levels of body dissatisfaction. This is of note because, while not all women who report concern for their shape develop disordered eating behaviours (Tylka, 2004), it is well documented that high levels of body dissatisfaction strongly predict future ED symptomology (Polivy & Herman, 2002). Given that this study demonstrates a negative association between SR capacity and levels of body dissatisfaction, this could suggest that SR may serve as an earlier indicator of susceptibility to disordered eating habits through disturbances in body image.

Moreover, our results found no association between SR and the EAT-26 subscales, *Dieting* and *Oral Control*, respectively. This is interesting given previous evidence suggesting an association between SR dysregulation and AN (Karwautz et al., 2001). Although the EAT-

26 does not identify eating attitudes for any type of ED specifically, it does utilise validated subscales which can serve as a guide in understanding particular disordered eating behaviours and their association with various EDs. Our results tentatively suggest that at least in the general population, reduced SR might be a stronger predictor of BN susceptibility compared to AN.

While these significant associations were found between SR and a number of variables, the proportion of variance which SR explains is still very low and the results must therefore be interpreted with caution. The development of disordered eating behaviours and negative body image is multifactorial, with factors such as family focus on appearance and participant proneness to anxiety having been show to account for 42% of variance in weight preoccupation, which is a common symptom of EDs (Davis et al., 2004). Moreover, media influence has been shown to play a large part in influencing eating habits and body image among adolescents, in particular (Derenne & Beresin, 2006). And while body positivity movements are becoming more prominent (Oinonen, 2021), the wide age range in the current study means it is likely that many participants were subjected to unrealistic and unhealthy media portrayals of women during their formative years (Wardrop, 2009).

3.5.1 Constraints on Generality

One potential limitation of the present study was the lack of attention questions included in the design of the online survey, meaning there was no quantitative method of ascertaining participant engagement level while completing the study. A lack of randomisation of the questionnaires also meant that the results may have been susceptible to order effects. Furthermore, some evidence suggests that online studies are not sufficiently demographically diverse (Krantz & Dalal, 2000), meaning that the external validity of the present results is

uncertain, particularly as participants were not asked to disclose their level of education nor ethnicity. Future research should address these potential confounding factors.

In conclusion, the results of this study demonstrated the impact that reduced SR capacity may play in the development of negative eating attitudes and body dissatisfaction among women within the general population, and suggest that SR may play an important role in the development of EDs. Future research is clearly needed, but SR difficulties or impairments could aid in the identification of women with increased vulnerability to develop an ED. However, given the small amount of variance SR explained among the variables, there are clearly other factors, such as family engagement, anxiety, and media influence, at play which can also help us understand why women come to develop disordered eating behaviours.

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3.7

Table 1

Participant Categorisations on the Eating Attitudes Test (EAT-26) and Body Shape Questionnaire (BSQ)

	N (%)
EAT-26	
No concern about eating	*N* = 191 (85.7)
Significant concern about eating	*N* = 32 (14.3)
BSQ	
No concern for shape	*N* = 77 (34.5)
Mild concern for shape	*N* = 62 (27.8)
Moderate concern for shape	*N* = 46 (20.6)
Marked concern for shape	*N* = 38 (17.1)

3.8

Table 2

Correlations Between Scores Across Questionnaires and their Subscales

	1	2	3	4	5	6
1. SSRQ	1					
2. EAT-26 Dieting	-.08	1				
3. EAT-26 Bulimia and Food Preoccupation	-.23**	.66**	1			
4. EAT-26 Oral Control	-.02	.28**	.14*	1		
5. EAT-26 Total	-.13*	.95**	.79**	.46**	1	
6. BSQ	-.21**	.71**	.61**	.06	.68**	1

** p<.05, **p<.01*

3.9

Table 3

Regression Statistics

	β	*t*	*SE*	*R*	R^2	ΔR^2
EAT-26	-.08	-1.99*	.04	.13	.02	.01
Dieting	-.03	-1.19	.03	.08	.006	.002
Bulimia & Food Preoccupation	-.05	-3.56***	.01	.23	.05	.05
Oral Control	-.003	-.36	.01	.02	.001	-.004
BSQ	-.48	-3.14**	.15	.21	.04	.04

** p<.05, **p<.01, ***p<.001*

Chapter 4

Paper 2:

The role of self-regulation in type 1 diabetes disordered eating (T1DE) and insulin omission: a questionnaire study

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4.1 Abstract

Objectives - Type 1 diabetes (T1D) requires high levels of daily self-regulation (SR) to maintain blood glucose control. T1D disordered eating (T1DE) is common, particularly in women. A significant proportion of T1Ds report omitting insulin as a weight loss method (IO), which can cause long-term morbidity and mortality. This study aimed to determine the role of SR in T1DE, and specifically whether SR would predict IO.

Design - The Short Self-Regulation Questionnaire (SSRQ), Eating Attitudes Test (EAT-26), Body Shape Questionnaire (BSQ), and Diabetes Eating Problem Survey – Revised (DEPS-R).

Participants - 143 UK women, aged 18-50, formally diagnosed with T1D.

Main Outcome Measures – Determining the role of SR as a predictor of T1DE and IO in women with T1D.

Results – Reduced SR significantly predicted increased scores the EAT-26, BSQ, and DEPS-R. SSRQ scores accounted for 11% of variance on the EAT-26 *Bulimia and Food Preoccupation* subscale, and 11.1% of variance on the BSQ. SSRQ scores also accounted for 21.5% of variance of the DEPS-R total score, and 8.5% of variance on the *Maintaining High Blood Glucose to Lose Weight* DEPS-R subscale, indicating engagement in IO. 21.7% of participants exceeded the threshold on the EAT-26 indicating significant eating concern, compared to the 62.2% over the threshold indicating T1DE on the DEPS-R.

Conclusions – SR plays a significant role in the development and maintenance of T1DE. These results are also the first to discover the role that SR plays in the engagement of IO, and suggests that interventions designed to improve SR could reduce future morbidity and mortality for these patients. The EAT-26 is not specific enough to assess disordered eating behaviour among women with T1D, and using such could result in patients with T1DE being missed. Healthcare practitioners should utilise the condition specific DEPS-R to assess for T1DE and IO.

Keywords: type 1 diabetes, disordered eating, eating disorder, T1DE, insulin omission, diabulimia, self-regulation

4.2 Introduction

Type 1 diabetes (T1D) is a condition in which the insulin-producing beta cells of the pancreas are destroyed by the immune system, meaning the body is unable to regulate its own blood glucose levels. People living with T1D must therefore self-administer insulin manually, either through injections or via an insulin pump. Without sufficient insulin, removal of glucose from the blood stream is reduced, leading to hyperglycaemia (high blood glucose). Prolonged hyperglycaemia can cause rapid weight loss, meaning that people with T1D can choose to purposely omit insulin as a method of weight loss (IO).

Daily management of T1D is extensive. Individuals must carefully monitor their blood glucose levels frequently throughout the day, calculate their food (particularly carbohydrate) intake, be mindful of their activity levels, identify how hormonal changes may be impacting their insulin sensitivity, and even consider fluctuating weather conditions, to name but a few. Such is the responsibility of managing the condition, that Anderson (1995) stated that 95% or more of the daily care of people with diabetes is carried out themselves. This constant monitoring of their internal and external environment requires high levels of self-regulatory control. This can take a toll, as research indicates that up to two thirds of people with T1D report feeling overwhelmed by their diabetes care (Malerbi et al., 2012). It may also explain why a number of mental health conditions are found to be more prevalent among people with T1D, including depression (Anderson et al., 2001), anxiety (Northam et al., 2005), and eating disorders (EDs; Goebel-Fabbri, 2009).

Increased body dissatisfaction has been identified among individuals with T1D. This could be due to the, often, sudden weight increase (following weight loss as a result of hyperglycaemia) associated with commencement of an insulin regime upon diagnosis (Larger, 2005; Starkey & Wade, 2010), or may be as a consequence of weight monitoring during medical check-ups (Hall et al., 2021). Individuals with T1D are argued to have a higher

prevalence of disordered eating and EDs than non-diabetic individuals of similar age and sex, and the presence of T1D and associated disordered eating is now commonly referred to as T1DE. In a study of adolescent girls, Engström and colleagues (1999) found that those with T1D were significantly more likely to demonstrate disordered eating behaviours compared to their non-diabetic peers, and evidence has suggested that women with T1D are three times more likely to develop an ED (Young et al., 2013). Furthermore, a meta-analysis found an increased prevalence of bulimia nervosa, specifically, in adolescent girls and women with T1D (Mannucci et al., 2005). The aetiology behind this increase has been demonstrated to be due to a variety of factors, including greater susceptibility to depression (Anderson et al., 2001), stigma surrounding the development of T1D (Jeong et al., 2018), increased susceptibility to weight gain (Corbin et al., 2018), and the daily focus put on food and eating (Pinhas-Hamiel et al., 2015). Moreover, T1DE has been associated with a marked increase in average blood glucose levels (HbA1c; Affenito & Adams, 2001; Figueroa et al., 2010). This could suggest that T1DE causes struggles in blood glucose management as a consequence of disordered eating practices.

Alternatively, this increase is HbA1c could be due to IO. Coined by the media as ‘diabulimia’, IO can have serious and potentially lethal consequences. Regardless of the risk, however, it is a behaviour found to be highly prevalent, with studies suggesting that up to 60% of people with T1D report IO (Deiana et al., 2016). Identifying risk factors associated with the development of IO is therefore of paramount importance. While increased weight concern and body dissatisfaction have previously been acknowledged as risk factors in the development of IO (Ackard et al., 2008; Hall et al., 2021), there is currently limited research attempting to understand potential mediating factors.

Self-regulation (SR) refers broadly to a cognitive process encompassing a number of cognitive functioning skills, which denotes to any attempt by the self to change or control one’s

inner state or responses (Vohs & Baumeister, 2004). This means that SR enables monitoring and adjusting thoughts, behaviours, impulses, emotions, and attentional processes to reach long-term goals (Nigg, 2017). As such, SR is considered a significant predictor of success in later life (Montroy et al., 2016). More specifically, deficits in SR have been associated with an array of behavioural and emotional disturbances, including depression (Strauman, 2002), anxiety (Kocovski & Endler, 2000), addiction (Zucker et al., 2011), and EDs (Cook-Cottone, 2015; Hall et al., 2021).

It has been suggested that SR capacity is limited. Known as the strength model of self-control (Baumeister et al., 2007), this theory posits that the enactment of SR in one situation drains capacity to self-regulate in a future situation, leading to subsequent SR failure. Moreover, it has been suggested that those with chronic depletion due to high SR demand are more likely to exhibit failures in regulating their behaviours (Wang et al., 2015), leading to less successful goal adherence. This might explain why SR deficits have been identified in chronic conditions such as T1D (Grylli et al., 2010), as the constant demands of managing the condition leaves individuals in a chronically depleted state, and thus more prone to unhealthy behaviours such as T1DE and IO. On the contrary, the need-to-belong theory (Baumeister and Leary, 1995) poses that when an individual experiences feelings of social isolation, despite them still having the cognitive capacity to enact SR they lack the necessary motivation to alter their behaviours which leads to subsequent SR failures. This is significant given that people with T1D can often feel stigmatised and excluded from society (Liu et al., 2017; Prell et al., 2023).

An emerging body of research is beginning to explore the role of SR in T1D. Wiebe and colleagues (2018) identified that high levels of SR served as a protective factor in diabetes management during emerging adulthood. Evidence has also demonstrated deficits in SR among adolescent girls with T1D and an ED on traditional measures like the Eating Disorder

Examination (EDE; Fairburn & Cooper, 1993; Grylli et al., 2010). However, there is currently little research examining the role of SR specifically in relation to T1DE, particularly in IO.

The current study therefore intended to explore the role of SR in eating attitudes, body satisfaction, and T1DE in women with T1D, with specific focus on a potential link between SR and T1DE, and IO, respectively. Disordered eating behaviours in women with T1D was assessed using traditional and diabetes-specific eating disorder (T1DE) measures to allow comparison between these assessment methods.

We predicted that lower SR to be associated with greater eating disturbances, lower body satisfaction, and greater incidences of T1DE. We also hypothesised that SR would significantly predict increased incidences of IO.

4.3 Methods

4.3.1 *Participants*

Following guidance of similar methodological design, and a power calculation of $\alpha = .05$, $\beta = .2$, and $r = .3$ which suggested a minimum sample size of 85 participants, a total of 143 women were recruited for the present study. Inclusion criteria required participants to be from the UK, aged 18-50 ($M = 29.85$, $SD = 8.18$), and have been formally diagnosed with T1D by a medical professional. Participants were recruited through online adverts across social media platforms, university disabilities services, charity posts, the Lancaster University Research Participation System, SONA, and the recruitment platform, Prolific. The study was approved by Lancaster University Faculty of Science and Technology Research Ethics Committee on 11/05/2021.

4.3.2 *Materials*

Short Self-Regulation Questionnaire (SSRQ; Carey et al., 2004)

A revised version of the original 62-item questionnaire developed by Brown and colleagues (1999), the SSRQ is a 34-item questionnaire designed to measure an individual's ability to self-regulate their behaviours (e.g. "*I don't seem to learn from my mistakes*"). The single-factor

measure uses a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The questionnaire has demonstrated high internal consistency (α = .92; Neal & Carey, 2005), and is correlated highly with the original 62-item questionnaire (*r* = .96; Carey et al., 2004).

Eating Attitudes Test – 26 (EAT-26; Garner et al., 1982)

This 26-item questionnaire is a standardized self-report measure used to assess eating attitudes and eating disordered characteristics. A 6-point Likert scale ranging from 1 (*always*) to 6 (*never*) codes responses from 0 to 3, allowing for a maximum score of 78. However, a score of equal to or greater than 20 may indicate cause for concern with regard to a participant's eating behaviour. The questionnaire measures three factors: *Dieting* (e.g. "*Am terrified of being overweight*"), *Bulimia and Food Preoccupation* (e.g. "*Find myself preoccupied with food*"), and *Oral Control* (e.g. "*Avoid eating when I am hungry*"). It has a strong internal consistency (α = .90; Garner et al., 1982) and has demonstrated test-retest reliability of up to .89 (Banasiak et al., 2001).

Body Shape Questionnaire (BSQ; Cooper et al., 1987)

The BSQ is a 34-item questionnaire measuring levels of body shape concern (e.g. "*Have you felt ashamed of your body?*") using a 6-point Likert scale ranging from 1 (*never*) to 6 (*always*), allowing for a maximum score of 204. The single-factor measure categorises scores less than 80 as indicating no concern for shape, 80-110 indicating a mild concern with shape, 111-140 indicating a moderate concern with shape, and over 140 a marked concern with shape (Taylor, 1987). The internal consistency of the questionnaire across different countries has shown to be high (α = .93 to .98; da Silva et al., 2014; Warren et al., 2008), and its temporal stability over 1 month is good (*r* = .81 to .95; Rousseau et al., 2005; Akdemir et al., 2012).

Diabetes Eating Problem Survey – Revised (DEPS-R; Markowitz et al., 2010)

A self-report measure for people with T1D, the DEPS-R is a 16-item diabetes specific questionnaire used to identify those at high risk of T1DE behaviours, including insulin IO. It uses a 6-point Likert scale ranging from 0 (*never*) to 5 (*always*), with a score of 20 or above suggesting T1DE (Markowitz et al., 2010). Confirmatory factor analysis has indicated a 3-factor structure of the questionnaire (Wisting et al., 2019). These factors are *Maladaptive Eating Habits* (e.g. "*I skip meals and/or snacks*"), *Preoccupation with Thinness or Weight* (e.g. "*Losing weight is an important goal to me*"), *and Maintaining High Blood Glucose to Lose Weight* (e.g. "*I try to keep my blood sugar high so that I will lose weight*"). The questionnaire has strong internal consistency (α = .86; Markowitz et al., 2010) as well as construct validity across cultures (Altınok et al., 2017; Karastogiannidou et al., 2021, Hummadi et al., 2023).

4.3.3 *Procedure*

Participants completed the study online via the hosting platform, Qualtrics (Qualtrics, Provo, UT). After providing informed consent and disclosing their age, participants completed the four questionnaires, SSRQ, EAT-26, BSQ, and DEPS-R. The order in which each questionnaire was presented was randomised, as was the order of questions within each questionnaire. Responses for each question were forced to ensure none were missed, and an additional response of 'prefer not to say' was included for each question to allow participants the opportunity to refuse to answer should they wish; any responses to this end were coded as missing data.

Participants were debriefed following the completion of all four questionnaires, and were guided to various helpful links (MIND, Diabetes UK, Beat, CALM) should they have experienced any emotional discomfort during the study. One participant recruited through the SONA platform was an undergraduate Psychology student, so received 1 research credit for

their participation. Non-undergraduate students who were recruited through SONA, and participants recruited through social media platforms, had the opportunity to enter a prize draw to win a £50 Amazon gift voucher. Participants who completed the study through Prolific received £2.50 compensation.

4.3.4 *Data Analysis*

Correlation analyses were initially conducted to assess the relationships between variables. A series of linear regressions were then carried out to examine the role of the SR capacity (SSRQ) on eating behaviours (EAT-26), body satisfaction (BSQ), and condition management (DEPS-R) in a female population with type 1 diabetes. Missing data (from responses of 'prefer not to say') were replaced using multiple imputation, whereby a total of 22 (<.01%) missing data points are substituted using predicted values.

4.4 Results

Data was analysed using SPSS version 27. Data was initially assessed for normality through Q-Q plots, boxplots, and collinearity statistics. A breakdown of scores for each questionnaire was first ascertained. Of the 143 participants, 31 (21.7%) scored over the threshold on the EAT-26 to indicate significant concern about eating, compared to 89 (62.2%) who scored over the threshold indicating T1DE on the DEPS-R. A full breakdown of categorised scores for each questionnaire can be found in Table 1.

Correlation analysis found a significant negative relationship between the SSRQ and the EAT-26 Total ($p < .05$), as well as its subscale *Bulimia and Food Preoccupation* ($p < .01$). SSRQ was also significantly negatively correlated to the BSQ ($p < .01$), the DEPS-R Total ($p < .01$), and all of the DEPS-R subscales (all $p < .01$). Correlation statistics can be found in Table 2.

A series of linear regressions were then conducted to assess the extent to which SSRQ scores predicted scores on the EAT-26, BSQ, and DEPS-R, respectively. Analysis demonstrated that for EAT-26 Total scores, SSRQ contributed significantly to the regression model, $F(1, 142) = 5.44$, $p = .02$, accounting for 3.7% of variance. Of the EAT subscales, only the *Bulimia and Food Preoccupation* model was significant, $F(1, 142) = 17.38$, $p < .001$, with SSRQ scores accounting for 11.0% of variance. No significance was found on the *Dieting* or *Oral Control* subscales (both $p > .05$). SSRQ was found to contribute significantly to BSQ variance, $F(1, 142) = 17.65$, $p < .001$, accounting for 11.1% of variance. A significant contribution of the SSRQ on the DEPS-R Total score was also found, $F(1, 142) = 38.64$, $p < .001$, with 21.5% of variance being accounted for. This significance was also reflected within the DEPS-R subscales; on the *Maladaptive Eating Habits DEPS-R subscale*, $F(1, 142) = 37.26$, $p < .001$, accounting for 20.9% of variance; on the *Preoccupation with Thinness or Weight* subscale, $F(1, 142) = 25.27$, $p < .001$, accounting for 15.2% of variance; and *Maintaining High Blood Glucose to Lose Weight* subscale, $F(1, 142) = 13.04$, $p < .001$, accounting for 8.5% of variance. Further regression statistics can be found in Table 3.

4.5 Discussion

The aim of this study was to explore the role of SR on eating attitudes, body satisfaction, and T1DE in women with T1D, particularly its impact on the development of IO. The results found strong evidence to support our hypotheses that SR would play a major role in predicting these behaviours. More specifically, SR was a significant predictor of ED pathology among women with T1D across each of the EAT-26, BSQ, and DEPS-R. Those who scored lower in SR capacity reported greater disordered eating behaviours, and had a more negative body image. Particularly in the case of T1DE behaviour (DEPS-R Total), SR explained a total of 21.5% of variance, indicating that as levels of SR reduced, incidences of T1DE increased. This indicates

that women with T1D who demonstrate reduced SR are at significantly greater likelihood of developing T1DE. This supports previous findings of a link between SR deficits and EDs in women with T1D (Grylli et al., 2010). It is important to note that Grylli et al.'s study used the EDE (Fairburn & Cooper, 1993), which is non-specific to people with T1D. In contrast, the DEPS-R contains questions designed to assess behaviours specific to those living with T1D, such as managing blood glucose and injecting insulin, in relation to eating attitudes and body shape. The present study is therefore the first to identify a significant SR deficit in females reporting T1DE as measured using the DEPS-R.

On the *Maintaining High Blood Glucose to Lose Weight* subscale, 59 (41.25%) of participants reported a positive (>0) score, indicating some level of IO. This aligns with previous research which has found similarly high prevalence rates among adolescents and young adults (Jones et al., 2000; Rydall et al., 1997), and suggests that it is a behaviour which continues into adulthood. It ought to be noted, however, that these behaviours may not only represent a desire to lose weight, as insulin omission can sometimes be utilised as a form of self-harm (see Ottawa Self-Injury Inventory; Nixon et al., 2015). This is because allowing blood glucose to greatly increase can cause high levels of physical discomfort and therefore a level of self-injury.

Critically, this study also found evidence that SR plays a role in IO, explaining 8.5% of variance on the *Maintaining High Blood Glucose to Lose Weight* subscale. This provides further explanation to the work of Wiebe and colleagues (2018), who, in a review of the available literature, found evidence that high levels of SR served as a protective factor in diabetes management. Therefore, the findings of the current study are the first of their kind to specifically identify the role that SR deficits play in the development of IO.

This study also found evidence to suggest the role of SR deficits in the development of negative body attitudes in women with T1D, with SR explaining 11.1% and 15.2% on the BSQ

and the DEPS-R *Preoccupation with Thinness or Weight* subscales, respectively. Additionally, almost half (46.2%) of participants reported either moderate or marked concern for their shape. These results support previous findings which demonstrated that a large proportion of adolescents with T1D report high levels of body dissatisfaction (Araia et al., 2017), and suggest that these levels of dissatisfaction continue into adulthood. The current findings also add to the knowledge base by highlighting the role that SR has in the continuation of these negative attitudes which can lead to insulin omission for weight loss. In addition, the significant correlation between BSQ scores and DEPS-R *Maintaining High Blood Glucose to Lose Weight* subscale scores (d = .43) supports previous findings suggesting that those with T1D are more likely to restrict or omit insulin if they report body dissatisfaction (Ackard et al., 2008). This highlights the complex nature of IO and suggests that deficits in SR may provide an earlier indicator to its development than body dissatisfaction.

In terms of outcome measures derived from the different eating behaviour questionnaires we found some notable discrepancies. On the EAT-26 questionnaire, 21.7% of participants scored on or above the recommended cut-off score of 20 to indicate cause for concern with regard to eating behaviour. This almost triples on the DEPS-R, with 62.2% of participants scoring equal to or over the 20-cut-off point to indicate T1DE. These findings suggest that traditional questionnaires such as the EAT-26 lack the sensitivity necessary to measure T1DE and its specific associated behaviours. Based on our findings, clinicians could miss over 40% of respondents with potential eating issues if using the EAT-26 as an indicator of disordered eating in T1D. Given the severe consequences of engaging in T1DE, particularly if IO is being utilised, using the EAT-26 as opposed to the DEPS-R to assess disordered eating in individuals with T1D could have serious ramifications. These include vision loss (retinopathy), nerve damage (neuropathy), kidney problems (nephropathy), and early mortality (Hall et al., 2021).

One limitation of the current research is that no data were collected regarding age of T1D diagnosis, nor the length of time since diagnosis. Previous research has suggested that there may be a relationship between age at diagnosis and glycaemic control, whereby those diagnosed at a younger age had greater difficulty regulating their HbA1c (Wiebe et al., 2005). Furthermore, if SR capacity is considered as a finite store (Baumeister et al., 2007) which T1D management is continuously depleting, then it would stand to reason that those who had the condition for longer may have a stronger reduction in capacity as they have had to manage the condition for longer. Based on the previous findings of chronic depletion as a result of prolonged SR control (Wang et al., 2015), further longitudinal research will help us understand how SR is impacted following T1D diagnosis, and gain a clearer idea of the potential effect of SR depletion in T1D management, particularly in developing IO behaviours. Furthermore, if this failure in SR is a result of feelings of isolation, as posed by the need-to-belong theory (Baumeister & Leary, 1995), then including an additional measure such as the need-to-belong scale (Leary et al., 2013) would provide greater clarity as to the cause of these SR deficits.

Given that this study included no control participants, it is also difficult to make inferences on how SR varies between those who have T1D and those who do not. It is therefore uncertain whether chronic condition management in women with T1D is causing depletion of SR stores or whether other factors are mediating or moderating SR depletion in this group. However, when comparing SR scores observed in this study to a methodologically similar study using females in a general population (Hall et al., in prep), the results suggest that women with T1D score significantly lower on the SSRQ than women in the general population, therefore indicating greater SR deficits in those with T1D. A future study which provides direct comparison of the two populations is required.

It also ought to be noted that the DEPS-R is not fully holistic as it does not capture all disordered eating behaviours, for example other purging methods like over-exercising or

laxative use. Its use as a clinical assessment for disordered eating among individuals with T1D should perhaps therefore be utilised alongside a broader measure such as the EAT-26, or follow-up assessment should occur through clinical interview.

4.6 Conclusion

The current study, to the best of the authors' knowledge, is the first to identify the role of SR deficits as a predictor in T1DE and IO, which can lead to significant long-term health consequences and premature death. Future research should examine this relationship across developmental stages, as SR is proposed to continue developing throughout childhood and adolescence, and into adulthood, and explore whether the development of SR is disrupted due to chronic depletion as a result of T1D management. In addition, the moderating role of age of diagnosis and length of living with the condition needs to be explored. While SR explained over a fifth of the variance in DEPS-R Total scores, there was still a large portion for which it did not account for. Examining other factors, such as those suggested above, is therefore necessary. Nevertheless, these findings provide important preliminary evidence for the role of SR in IO which might help inform future interventions. Furthermore, these results demonstrate important implications for healthcare professionals, and suggest that the DEPS-R should be utilised as a diagnostic tool for T1DE over generic ED questionnaires like the EAT-26, to ensure that no patient struggling with T1DE is overlooked.

4.7 References

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4.8 Additional Information

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4.8.2 Competing Interests

The authors declare no competing interests.

4.8.3 Contributors

RH was responsible for the design, recruitment, analysis, and write up of the study. MT advised on the design and analysis, participated in the review process and made significant contributions to the final version of the article. SSL also participated in the review process and made contributions to the final article.

4.8.4 Patient and public involvement

It was not appropriate to have patient or public involvement in the design, or conduct, or reporting, or dissemination plans of our research.

4.8.5 Patient consent for publication

Not required.

4.8.6 Ethical approval

Ethics approval for the original study was granted by Lancaster University Faculty of Science and Technology Research Ethics Committee on 11/05/2021.

4.8.7 Data availability statement

Data is available upon reasonable request.

4.9

Table 4

Participant Categorisations on the Eating Attitudes Test (EAT-26), Body Shape Questionnaire (BSQ), and Diabetes Eating Problem Survey – Revised (DEPS-R)

	N (%)
EAT-26	
No concern about eating (<20)	*N* = 112 (78.3)
Significant concern about eating (20+)	*N* = 31 (21.7)
BSQ	
No concern for shape (<80)	*N* = 38 (26.5)
Mild concern for shape (80-110)	*N* = 39 (27.3)
Moderate concern for shape (111-140)	*N* = 35 (24.5)
Marked concern for shape (>140)	*N* = 31 (21.7)
DEPS-R	
No disordered eating (<20)	*N* = 54 (37.8)
Disordered eating (20+)	*N* = 89 (62.2)

4.10

Table 2

Correlations Between Scores Across Questionnaires and their Subscales

	1	2	3	4	5	6	7	8	9	10
1. SSRQ	1									
2. EAT-26 *Dieting*	-.16	1								
3. EAT-26 *Bulimia and Food Preoccupation*	-.33**	.71**	1							
4. EAT-26 *Oral Control*	.08	.32**	.22**	1						
5. EAT-26 Total	-.19*	.95**	.84**	.50**	1					
6. BSQ	-.33**	.67**	.53**	.09	.63**	1				
7. DEPS-R *Maladaptive Eating Habits*	-.46**	.48**	.55**	.03	.50**	.57**	1			
8. DEPS-R *Preoccupation with Thinness or Weight*	-.39**	.53**	.44**	.03	.50**	.74**	.65**	1		
9. DEPS-R *Maintaining High Blood Glucose to Lose Weight*	-.29**	.50**	.56**	.26**	.57**	.43**	.64**	.59**	1	
10. DEPS-R Total	-.46**	.56**	.58**	.07	.57**	.68**	.95**	.84**	.77**	1

** p<.05, **p<.01*

4.11

Table 5

Regression Statistics

	β	*t*	*SE*	*R*	R^2	ΔR^2
EAT-26	-.14	-2.33*	.06	.19	.04	.03
Dieting	-.08	-1.93	.04	.16	.03	.02
Bulimia & Food Preoccupation	-.08	-4.17***	.02	.33	.11	.10
Oral Control	.01	.99	.01	.08	.01	.00
BSQ	-.80	-4.21***	.19	.33	.11	.11
DEPS-R	-.41	-6.22***	.07	.46	.22	.21
Maladaptive Eating Habits	-.25	-6.10***	.04	.46	.21	.20
Preoccupation with Thinness or Weight	-.12	-5.03***	.02	.39	.15	.15
Maintaining High Blood Glucose to Lose Weight	-.04	-3.61***	.01	.29	.09	.08

** p<.05, **p<.01, ***p<.001*

Chapter 5

Paper 3:

Examining implicit biases towards high and low carbohydrate foods in people with type 1 diabetes, and the relationship with self-regulation

Rebecca Hall

5.1 Abstract

Type 1 diabetes (T1D) is a chronic health condition which necessitates daily food monitoring in order to calculate carbohydrate consumption, and deliver appropriate insulin doses to maintain blood glucose levels. Previous research has indicated an increased risk of disordered eating among individuals with T1D, which is suggested to be partly due to the focus placed on food and eating. Further research has demonstrated that levels of disordered eating in T1D are correlated with the ability to self-regulate. The present study was therefore interested in exploring whether the increased demand on self-regulation (SR) for high carbohydrate foods was associated with implicit food biases in individuals with T1D. A pilot study was first conducted where women were asked to categorise a number of food stimuli based on their carbohydrate content and healthiness. Based on these results, the most concurrent foods were utilised as priming stimuli in an implicit bias task undertaken by women with T1D (N = 30) and controls (N = 30). The results opposed our hypothesis, whereby low carbohydrate foods were associated with negative implicit bias, and high carbohydrate foods were associated with positive bias. A mediatory role of SR was also found in these biases, suggesting a greater cognitive effort was necessary to process low carbohydrate foods. These findings suggest that daily carbohydrate counting does not explicitly cause deficits in SR in women with T1D. Future research may wish to explore this effect longitudinally, and explore whether these findings are consistent across different time periods.

5.2 Introduction

Type 1 diabetes (T1D) is a chronic health condition which requires the individual with the condition to take on over 95% of its daily management (Anderson, 1995). One of the many aspects of managing T1D is the monitoring of food intake, as any carbohydrate consumed is converted into simple sugars which subsequently impact blood glucose levels, meaning an appropriate insulin dose must be calculated and administered prior to eating. In order to reduce dietary restrictions and allow for greater flexibility with regard to eating habits, people with T1D are often encouraged to undertake the Dose Adjustment for Normal Eating (DAFNE) course. This teaches patients the theoretical basis of carbohydrate counting and subsequently appropriate insulin dose calculations (Gunn & Mansell, 2011). Knowledge of this then gives patients greater dietary freedom, by giving them the skills to calculate carbohydrate content while managing the subsequent effect to blood sugar levels. DAFNE has been shown to improve HbA1c, reduce severe hypos and restore hypo awareness, reduce psychological distress, and improve perceived wellbeing (Hopkins et al., 2012).

However, Mehta et al (2009) found that the emphasis placed on carbohydrates may negatively influence general dietary patterns in people with T1D, as focus groups of young people indicated that pre-packaged food options (i.e. containing nutrition labels with the exact carbohydrate content of a product, therefore removing any necessary calculations) were preferred to whole fresh foods. Furthermore, a similar interview study found that after converting to flexible intensive insulin therapy, meaning that carbohydrate counting was required before consuming foods, the emphasis on carbohydrates caused individuals with T1D to feel that low/no carbohydrate foods were the healthiest and safest food options (Lawton et al., 2011). While these qualitative methodology studies allow for a deep understanding of the subject from the perspective of those involved (Denzin & Lincoln, 2000), such self-report

measures are limited due to their reliance on explicit processes which are subject to confirmation bias, social desirability, and self-presentation (Lamote et al., 2004).

Quantitative studies have revealed further costs associated with the dietary focus necessary to manage T1D. Pereira & Alvarenga (2007) found that extreme carbohydrate counting and meal planning was associated with increased food preoccupation among women with T1D. Further research suggests that almost a quarter of adolescents with T1D restrict their diet in an effort to lose weight (Neumark-Sztainer et al., 1996). Individuals, particularly women, with T1D therefore appear susceptible to developing negative food biases as a result of the preoccupation with carbohydrate counting, which can lead to the development of disordered eating practices. There can also be a subsequent association developed between insulin and weight gain among these individuals, as there is the belief that insulin is the contributary factor in weight gain (which could be due to the typical weight gain at the point of diagnosis and commencement of insulin therapy; Hall et al., 2021). This can cause some to intentionally omit insulin as a method of weight loss (IO), which can lead to significant long-term physical health consequences.

The dietary focus as a result of DAFNE may then go at least part of the way to explaining why people with T1D are more likely to develop issues with food (Goebel-Fabbri, 2009; Hanlan et al., 2013), with rates of comorbid T1D and disordered eating (T1DE) suggested to be significantly higher than rates of disordered eating in the general population (Hall et al., 2021; Mannucci et al., 2005). Consistent daily focus on food and dietary monitoring requires significant self-regulatory control, which may also play a contributory role in T1DE and IO. Self-regulation (SR) is a cognitive process which allows individuals to observe and alter their emotions and behaviours, to enable the attainment of a long-term goal (Nigg, 2017). The consistent requirement for individuals with T1D to utilise SR to calculate their carbohydrate intake and examine other factors (i.e. level of exercise, hormonal impact etc)

before calculating an appropriate insulin dose may cause a depletion in available SR resources (Baumeister et al., 2007). Foods that have a greater carbohydrate content may therefore require greater SR effort in order to calculate their nutritional value. Moreover, the stigma individuals with T1D often feel around food may cause them to lack the necessary motivation to manage their condition (Browne et al., 2014). Regardless of the associated cognitive model, research indicates that SR deficits or failures are present in individuals with T1D (Grylli et al., 2010; Hall et al., 2023), and that this poor SR is significantly associated with increased rates of T1DE and IO (Hall et al., 2023).

Individuals with T1D may therefore develop negative food associations towards high carbohydrate foods, as they place a greater demand on SR capacity which research suggests is already depleted (Hall et al., 2023). Understanding implicit food biases among individuals with T1D would therefore allow for a greater understanding of the subconscious relationship between carbohydrate counting, food preoccupation, and the impact on SR, which could then help inform future patient practice. One method of observing these implicit associations is through the use of attentional bias tasks.

A variety of attentional bias tasks have been developed to help understand implicit associations and cognitive biases. Variations on the Stroop test of reaction times between congruent and incongruent stimuli, for example, were popular in the late 80s and 90s as a method of assessing food and body disturbances among patients with eating disorders (EDs). Stroop effects have been found in anorexia nervosa (AN), where patients show greater distraction to shape concerns in a manipulation to the classic test which instead used body shape terms (Dobson & Dozois, 2002). Similar results have been found in bulimia nervosa (BN) patients who showed an interference effect in a Stroop task which used food-related terms (Formea & Burns, 1996).

Priming studies have also been explored as a method of indirectly examining food attitudes, which work on the premise that participant response to a target stimulus (e.g. evaluating the valence of a word) is quicker and more accurate when prefaced with a congruent priming stimulus (Fazio et al., 1986). This concept has been adjusted to examine implicit biases in a wide range of populations, including those with EDs. In one such study, researchers discovered that AN patients showed no palatability priming effect to foods, unlike controls, demonstrating that those living with AN may refrain from seeing palatability as a characteristic within food (Roefs et al., 2005). Furthermore, Blechert and colleagues (2010) found a shape/weight priming effect associated with self-evaluation in BN patients, suggesting that disturbances in shape and weight are intrinsically linked to the development of ED symptoms. Despite the necessitated focus which is placed upon food in people with T1D to adequately manage their blood glucose levels, there is currently extremely limited research utilising affective priming paradigms to assess food associations and their links to the development of disordered eating habits and insulin as a method of weight loss among the T1D population.

The present study therefore hypothesises that high carbohydrate foods will be associated with greater errors and longer reaction times in the evaluative priming task among people with T1D compared to controls, indicating an implicit negative bias towards these high carb foods. Moreover, we propose that these negative biases will be associated with significantly reduced scores on the SSRQ, indicating depleted SR capacity among the T1D cohort compared to controls.

5.3 Pilot Study

A pilot study was initially devised to ensure the robustness of the priming stimuli used within the main study.

5.3.1 Methods

5.3.1.1 Participants. The pilot study recruited a cross-section of 40 female participants based on a power calculation of $\alpha = .05$, $\beta = .2$, $q_1 = .5$, $q_0 = .5$, $\eta^2 = 1$ and $sd = 1$ which suggested a minimum sample size of 34 participants from the UK general population, as determined by the inclusion criteria to align with the main study. Ages ranged from 21 to 74 years ($M = 37.88$, $SD = 15.12$). Participants were recruited through the online recruitment platform, Prolific. All participants had an active Prolific account and had been active within the past 90 days. The study received ethics approval from the Faculty of Science and Technology Ethics Committee at Lancaster University on 01/12/2021.

5.3.1.2 Materials. Photographs of food items were located through free licence websites, freerangestock.com, and freeimages.com. Photographs were selected based on their carbohydrate, extrinsic sugar, and saturated fat content. Foods with a carbohydrate content greater than 10 grams per 100 grams were categorised as high carbohydrate, while those below that were categorised as low carbohydrate. Foods with extrinsic sugars and/or saturated fat content greater than 10 grams per 100 grams were categorised as unhealthy, while those below that were categorised as healthy. Four categories of photographs were therefore created: high carbohydrate/healthy, high carbohydrate/unhealthy, low carbohydrate/healthy, low carbohydrate/unhealthy. A total of 78 photographs were selected based on these criteria, 19 in each category. All images were then subjected to background removal through the website remove.bg, and resized using Adobe Spark.

A Qualtrics questionnaire was then developed using these edited photographs. Each photograph was presented on a separate page along with two questions: “Would you consider this food high carbohydrate or low carbohydrate?”, and “Would you consider this food healthy or unhealthy?”. Presentation of all photographs was randomised, and a check question was also randomly presented to ensure participant attention.

5.3.1.3 Procedure. After selecting to participate in the study on the Prolific platform, participants followed a link to the Qualtrics questionnaire. Following the providing of informed consent, participants categorised the 78 photographs by selecting the response, "high carbohydrate" or "low carbohydrate", and "healthy" or "unhealthy". All responses were forced in order to eliminate the possibility of accidental non-response. Participation took approximately 10 minutes, although a maximum completion time of 44 minutes applied. Once complete, participants received monetary compensation of £1.25.

5.3.1.4 Data Analysis. Participant responses were coded as either correct or incorrect on carbohydrate content and healthiness for each photograph stimulus. Descriptive statistics were then calculated using SPSS Version 17.

5.3.2 Results

Responses for each factor (carbohydrate content and healthiness) on each photograph were summed, and a mean average was taken for each which represented the proportion of correct answers per stimulus. The 10 photographs from each category with the highest number of correct global responses were chosen for use in the main study (see Appendix B), so 40 photographs were selected in total. In the event that two photographs had the same mean score, the stimulus with the smallest range of correct to incorrect answers was selected. On one occasion, where the range between two stimuli were identical, one stimulus was selected at random.

5.4 Main Study

5.4.1 Methods

5.4.1.1 Participants.

The main study recruited 30 females with T1D, and 30 females without T1D as control participants, based on a power calculation of $\alpha = .05$, $\beta = .2$, $q_1 = .5$, $q_0 = .5$, $\eta^2 = .8$ and $sd = 1$ which suggested a minimum sample size of 52 participants. Inclusion criteria required all participants to be from the UK, and be aged between 18 and 50 years old. Of the females with T1D, 8 (26.7%) reported their age between 18 and 25, 15 (50.0%) reported their age between 26 and 35, and 7 (23.3%) reported their age between 36 and 50. Of the control females, 10 (33.3%) reported their age between 18 and 25, 12 (40.0%) reported their age between 26 and 35, and 8 (26.7%) reported their age between 36 and 50. All participants were recruited through the Prolific recruitment platform. Participants with T1D had previously confirmed through the Prolific demographic information that they were diagnosed with the condition, and were therefore only able to complete the study based on this. Control participants were asked to ensure prior to their completion of the study that they did not have T1D.

5.4.1.2 Materials.

Priming Photographs. The 40 photographs previously selected in the pilot study were used as priming stimuli.

Target Word Stimuli. The target words for the main study were sourced using SentiWords, an open access resource of over 155,000 words categorised on a polarity scale of -1 (very negative) to +1 (very positive). All negative words with a polarity of <-.7 ($n = 66$), and positive words with a polarity of >.7 ($n = 31$), were initially identified using the resource, and were then analysed based on length of word and polarity dimension. A total of 20 negative words (average length = 6.4 letters, average polarity = -.78) and 20 positive words (average length = 6.7 letters, average polarity = .75) were identified for inclusion in the final study. Words did not differ significantly on word length, $t(22.2) = -.75$, $p = .46$, or respective polarity (positive or negative), $t(38) = 2.02$, $p = .05$.

Short Self-Regulation Questionnaire (SSRQ; Carey et al., 2004). This 31-item questionnaire measures the ability of an individual to self-regulate their behaviours. Revised from the original 62-item questionnaire by Brown and colleagues (1999), its single-facture structure measures responses on a 5-point Likert scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The SSRQ has demonstrated good internal consistency and validity (Šebeňa et al., 2018).

Evaluative Priming Task

An evaluative priming study was created on PsychoPy. In each trial, a priming stimulus was presented for 250ms, followed by 50ms of blank screen, followed by a target word which remained until a response was received. Prime stimuli were sized at 500 x 500 pixels and target words were presented as lowercase black letters in Arial font. The study consisted of a practice block of 10 trials, followed by four experimental blocks of 40 trials. The blocks were organised so that each photograph would act as a food prime for two positive words, and two negative words. No word or food prime was repeated within the same block, and no identical trials occurred between blocks.

5.4.1.3 Procedure. Participants were invited to take part in a reaction times study examining differences in reaction times across different groups of people. Following informed consent and demographic questions, participants were told that they would see a photograph which they were to ignore, followed by a word which they were to categorise as either ‘positive’ by pressing the ‘M’ key on their keyboard, or ‘negative’ by pressing the ‘Z’ key on their keyboard. To ensure familiarity with the controls, participants conducted 10 practice trials using food prime stimuli which was not selected from the pilot study, and target words identified for their polarity but discarded based on their length (i.e. too long or too short).

Following the practice trials, participants moved on to the main experiment consisting of four blocks. As in the practice trials, participants were shown a food prime then asked to

decide whether each word presented to them was positive or negative. Before each block there was a reminder of the controls, and no time limit was placed between blocks meaning participants continued when ready. Once all blocks were completed, participants completed the SSRQ questionnaire by using their mouse to select their response on the screen. An attention question asking participants to select a specific response was also included for data control purposes. Upon completing the experiment, participants were debriefed, and were guided to various helpful links (MIND, Diabetes UK, Beat, CALM) should they have experienced any emotional discomfort during the study.

5.4.1.4 Data Analysis. Correctness of categorising the target words, and reaction times, were collected for each trial. The data was cleaned to remove outliers, and data was assessed for normality through Q-Q plots, boxplots, histograms, and Mauchly's Test of Sphericity. Responses <0.2 seconds, or >2.0 seconds were removed. Responses quicker than .2 seconds would not allow for sufficient cognitive processing to occur, and were likely mis-clicks. Responses greater than 2 seconds allowed the participant to consciously think about their response, meaning they would not measure the implicit cognitive biases we were looking to explore. Out of a total of 9600 trials (60 participants with 160 trials per participant), 112 data points were removed as outliers, a percentage of .0117%.

Data was reduced to create a mean average score of correctness and reaction times for each interaction of within-subject variables. Data was analysed using a 2 (valence) x 2 (carbohydrate) x 2 (health) x 2 (diabetes status) mixed ANOVA and ANCOVA, with SR (SSRQ) score entered as a covariate. Diabetes status was a 2 level between-subjects independent variable (T1D versus control), and word valence (positive vs negative), carbohydrate (high vs low) and healthiness (healthy vs unhealthy) were all 2 level within-subjects independent variables. Individual ANOVA and ANCOVA was run for correctness and

reaction times. Between-group differences in SR were also explored through independent-samples t-test.

5.4.2 Results

In regard to correctness, when controlling for SR on the ANCOVA, there was a significant interaction observed between valence and carbohydrate, $F(1, 57) = 4.78$, $p = .033$. This indicated a congruency effect whereby participants demonstrated a cognitive disturbance on positive words x low carbohydrate foods ($M = .952$) and negative x high carbohydrate foods ($M = .957$). This disturbance meant that in the aforementioned conditions participants made more errors than in the positive x high carbohydrate foods ($M = .962$) or negative x low carbohydrate foods ($M = .971$) conditions. When removing the covariate, no significant interaction was found, $F(1, 58) = 2.51$, $p = .12$. No further significant main within- or between-effects were found, and no further significant interactions were observed between variables for correctness.

Considering reaction times, when controlling for SR through ANCOVA only the 3-way interaction of valence x carbohydrate x health was significant, $F(1, 57) = 5.25$, $p = .025$. See Table 1 and Figure 1. Following the removal of the covariate, there was a significant main effect of carbohydrate on reaction times, $F(1, 58) = 12.88$, $p = .001$, whereby high carbohydrate priming stimuli produced quicker reaction times ($M = .707$) than low carbohydrate priming stimuli ($M = .721$). There was also a significant interaction between valence and carbohydrate, $F(1, 58) = 21.07$, $p < .001$. Similar to the correctness findings, this indicated a congruency effect whereby participants demonstrated a cognitive disturbance on positive words x low carbohydrate foods ($M = .735$) and negative x high carbohydrate foods ($M = .728$). This disturbance meant that participants reacted slower in the aforementioned conditions than on positive x high carbohydrate foods ($M = .685$) or negative x low carbohydrate foods ($M = .707$).

The same significant 3-way interaction of valence x carbohydrate x health was also observed, but to a greater degree, $F(1, 58) = 12.75$, $p = .001$. See Table 1. No between-subject effects were observed for reaction times. There was no difference found in SR scores between the T1D group (M = 106.03, SD = 15.40) and the control group (M = 106.40, SD = 15.35), t(58) = -.09, p = .93.

Table 6

Mean reaction times of 3-way interaction

Valence	Carbohydrate	Healthiness	*M*	95% CIs
Positive	Low	Healthy	.720	[.686, .754]
		Unhealthy	.750	[.717, .784]
	High	Healthy	.694	[.664, .725]
		Unhealthy	.676	[.646, .706]
Negative	Low	Healthy	.716	[.685, .746]
		Unhealthy	.698	[.665, .731]
	High	Healthy	.713	[.684, .743]
		Unhealthy	.743	[.708, .778]

5.5 Discussion

Contrary to our hypothesis, analysis of correctness indicated a congruency effect whereby participants encountered a cognitive disturbance on positive x low carbohydrate food/negative x high carbohydrate food, indicating that high carbohydrate food was considered more desirable. This may oppose evidence suggesting that low carbohydrate foods are considered healthier and safer among people with T1D (Lawton et al., 2011), although it could instead speak to dietary preference despite the perceived healthiness. This effect was only found when

controlling for SR, which would suggest that SR played no role in this implicit bias. Conversely, however, the same congruency effect on the same interaction was found with regard to reaction time, but only when SR was not held constant, suggesting that SR did play a contributory effect on this interaction. In other words, this cognitive dissonance was also associated with an impact on self-regulatory capacity. This may be indicative of the SR burden that people feel when it comes to making food choices, and the motivation and enactment of SR that is required to make what are perceived as healthier choices.

Similar results were found in the main effect of carbohydrate, whereby high carbohydrate foods had quicker reaction times than low carbohydrate foods, indicating a positive implicit bias towards high carbohydrate foods. This is contrary to our hypothesis that negative food attitudes often observed in individuals with T1D are associated with the necessitation of carbohydrate counting. Instead, these high carbohydrate foods may be seen as more desirable due to negative social stigma associated with T1D and sugar (Browne et al., 2014) and, as such, individuals deprive themselves of these foods. This social stigma may also cause low carbohydrate foods to be less desirable. This could suggest that a greater cognitive effort and SR demand was placed on low carbohydrate foods, given that significance was only apparent without controlling for SR, as low carbohydrate foods require a greater level of SR motivation to consume. Furthermore, many of the high carbohydrate food priming photos used in the study were foods which would typically be pre-packaged, meaning T1D participants may have associated them with reduced anxiety (Mehta et al., 2009) as they would typically contain carbohydrate contents on their label, thus requiring them to exhibit less SR for these foods. It is, however, unclear as to why this same implicit bias is present among control individuals.

The lack of difference found in SR between the T1D and control groups on the SSRQ may be a result of the test design, whereby participants were asked to complete the SR questionnaire following completion of the implicit bias task to ensure there were no priming

effects from its questions. Based on Baumeister and Vohs' (2007) theory of 'ego depletion', all participants may have been suffering with similarly depleted SR stores following completion of the implicit bias task given the effort it required, and therefore both groups performed similarly on the SSRQ. Stroop tasks have previously been demonstrated to reduce SR capacity (Ferrari & Pychyl, 2007) which could explain why no difference was found between T1Ds and controls despite previous findings suggesting that there is a significant discrepancy between the two populations with regards to SR capacity (Hall et al., 2023). However, if 'ego depletion' were to explain chronically depleted SR among individuals with T1D, it could be argued that after completing the same implicit bias task there would still have been a discrepancy between the two groups on SR scores. This would suggest that the strength model of self-control (Baumeister et al., 2007) may not provide the most comprehensive explanation of the current findings.

Alternatively, these similar SR scores may instead provide evidence for self-efficacy and its role in SR. Overall performance between groups was similar, as no between-group effects were found, and therefore participants who believed they performed well in correctly categorising the target words may have perceived their SR to be of similar levels. Based on their feelings of self-efficacy, this may have had a subsequent effect of increasing motivations to monitor and amend behaviours associated with adequate SR (Bandura, 1997), and thus impacted their scores on the SSRQ.

There is also an argument that SR is an explicit measure and therefore not a true quantifier of cognitive bias. A recent review of implicit biases to food on EDs found that, in order to gain a full comprehension of the relationship between SR mechanisms and eating behaviours, it was necessary to collect both direct, self-report, measures, and indirect measures of explicit and implicit responses (Paslakis et al., 2021). This means that, alone, implicit bias tasks may not be powerful enough to identify food disturbances among people with T1D, but

alongside explicit food attitude questionnaires, for example, we could gain a better understanding of the link between relationships with carbohydrates and eating behaviours in people with T1D.

Furthermore, the implicit responses to the various food priming stimuli could have been impacted on an individual level by a number of various factors not captured within the study. For example, particularly given the high rates of comorbidity between T1D and coeliac disease (Elfström et al., 2014), foods which are typically gluten containing like pasta and bread may likely have elicited a different implicit response in individuals with coeliac disease compared to those without. Similarly, meat- or animal-based products such as the burgers and cheese may have been subject to varying biases in vegetarian and vegan participants than those who do not follow such lifestyle choices. Future research should either control for this during participant recruitment, or take a measure of these confounders during the procedure.

5.6 Conclusion

The findings of this study have demonstrated that both T1Ds and controls have negative implicit biases towards low carbohydrate foods, which was further demonstrated by an incongruency effect during the categorisation of high and low valence words. Moreover, there appears to be an mediating effect of SR on these implicit biases, although no differences between SR were found between groups. Future research may wish to deliver a two-part study whereby the SSRQ is completed at an early date than the implicit association task, to get a clearer picture of its covariate effect while eliminating priming effects, and to observe the true differences between individuals with T1D and controls.

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Chapter 6

Paper 4:

"This is an iceberg, and the bit people don't see is below the water": A qualitative inspection of women's experiences of living with type 1 diabetes

Rebecca Hall

6.1 Abstract

Type 1 diabetes (T1D) is a life-long condition which requires consistent daily management to maintain optimum blood glucose. The purpose of this study was to qualitatively examine the factors which women living with T1D found impacted their ability to manage condition, and explore how these related to feelings of self-regulatory capacity and feelings of self-efficacy. Six women with T1D participated in online semi-structured interviews where they could discuss their T1D management and identify barriers they perceived in this management. A total of five main themes were discovered: *Complexity and variability of condition management*, *Threats to self-efficacy*, *Impact on mental health*, *Social support*, and *Technological advances*. Within each of these themes were sub-themes which narrowed in on particular factors relating to feelings of cognitive capacity or self-efficacy. The impact that these themes highlight in regard to the effect living with T1D has on levels of self-regulation and feelings of self-efficacy are discussed. Proposals for protective factors and future interventions are also suggested.

6.2 Introduction

Type 1 diabetes (T1D) is a condition necessitating significant amounts of daily self-regulatory control, demanding calculation of carbohydrate consumption and associated insulin administration, as well as frequent monitoring of blood glucose (BG), throughout the day. The relentlessness of the condition may lead some people with T1D to lack the capacity or motivation required to attend to their daily management needs. This can cause poor treatment adherence and an increase in average BG levels (HbA1c), which is associated with a long-term increase in morbidity and mortality. It may also lead to the development of mental health conditions, such as depression, anxiety, and disordered eating.

Polonsky (1999) suggested that one of the biggest barriers for people with regard to their diabetes care is eating. While courses like Dose Adjustment for Normal Eating (DAFNE) can help provide individuals with T1D with the practical skills to adequately calculate carbohydrates and the subsequent necessary insulin dose, this forces a distinct focus on food, meaning that eating requires a significant cognitive effort. This spotlight on food and eating has been suggested to leave people with T1D more susceptible to developing issues around food (Goebel-Fabbri, 2009), and associated eating disturbances. T1D and associated disordered eating (T1DE) is highly common particularly among women, with research suggesting that upwards of 60% of women with T1D may also suffer from T1DE (Hall et al., 2023).

Although not yet classified as an official eating disorder (ED) within the DSM-V (American Psychiatric Association, 2013), T1DE is a highly complex and multifaceted condition whose focus is wider than food and eating, but also encompasses aspects of T1D management. Insulin omission (IO), for example, can exclusively be used by individuals with T1D as a method of weight loss, as without sufficient insulin the body must utilise fat stores as energy which can lead to a rapid reduction in weight. For many people living with T1D, there

is a significant amount of anger targeted towards their condition because of the restrictions they feel it places on their diet and lifestyle (Knight et al., 2003). In those with T1D who develop eating disturbances, engagement in behaviours like IO may then be more likely than calorie restriction or binge/purge behaviours, because of the anger they feel towards their condition. Recovery from T1DE is also more complex, as traditional ED recovery would suggest reducing focus around food, but this is not possible for people with T1D because of the consistent need to monitor food to manage their condition.

An emerging body of research has observed the role of self-regulation (SR) in T1D management. There are a number of theories of SR, but one which has received a wide amount of attention is the strength model of self-control (Baumeister et al., 2007), which suggested that the capacity to self-regulate is a finite store which becomes depleted following situations requiring high SR management. Based on this theory, individuals with T1D are consistently depleting their SR store due to the daily requirements of managing their conditions. This could result in a chronically depleted capacity to enact SR, and result in the development of eating disturbances and maladaptive behaviours such as insulin omission (IO), particularly if the individual also has body dissatisfaction or condition-directed anger (Hall et al., 2023).

An alternative theory of SR examines levels of self-efficacy, which impacts the motivation to continue working towards optimum condition management. Based on the work of social cognitive theory (Bandura, 1991), research has found that higher levels of self-efficacy are associated with greater adherence to condition management in T1D (Iannotti et al., 2006), because individuals have greater motivation to enact SR and attain a goal. Individuals who feel as though they are less competent or capable of meeting their treatment goals may therefore suffer failures in SR, whereby they have sufficient capacity but lack the motivation to elicit change. Similar to the strength model, if a person also has comorbid body image issues

and therefore a desire to lose weight, but a lack of motivation to enact change in a healthy way, they may be more susceptible to developing T1DE and engaging in IO.

While quantitative research methods allow us to observe statistical change and are more methodologically robust, they can also be restricting and may not fully capture the full story of an individual's experiences. Qualitative research may be more susceptible to confirmation bias and social desirability (Lamote et al., 2004), but such methodology also allows for a richer level of data collection, giving patients the opportunity to inform research in their own words and from their perspective (Denzin & Lincoln, 2000). The purpose of this qualitative study was therefore to gain a greater understanding of the daily demands and perceived difficulties faced by women with T1D, and understand how perceived SR capacity or motivation were related to their ability to manage their condition.

6.3 Methods

6.3.1 Participants

Inclusion criteria required all participants to be female, living in the UK, aged between 18 and 50, and have been formally diagnosed with type 1 diabetes by a medical professional. A total of 6 women, aged between 37 and 49 took part in the interviews, and by the sixth interview data saturation had been achieved (Braun & Clarke, 2021). Age of diagnosis ranged from 18 to 40, and length living with the condition ranged from 1 to 26 years. Descriptives can be found in *Table 1*.

6.3.2 Design

A semi-structured interview schedule was developed before interviews were conducted. Opening questions (e.g. "*tell me a bit about yourself* ") allowed participants to introduce themselves and feel more comfortable, meaning they were then more willing to open up about their diabetes management and a typical day living with their condition. The main questions

asked participants to evaluate their relationship with their diabetes (e.g. "*what's the most difficult thing for you about having diabetes?*"), as well as indirectly asking them to consider their self-regulatory capacity with regard to condition management, and more broadly (e.g. "*do you ever set yourself goals with regards to your diabetes management, or life in general?*"). Questions were chosen based on previous literature, as well as on the experience of the principal researcher. The semi-structured nature of the interviews allowed participants to discuss any topic they wished in as much detail as they were willing to offer, yet also allowed for flexibility within the discussion.

6.3.3 Procedure

All participants provided written informed consent prior to their interview. Interviews took place between January and February 2022 and were held online via Microsoft Teams, where they were recorded on permission of the participant. Interviews lasted between 48 and 69 minutes, averaging 54 minutes. Automatic transcripts were generated by Teams, which were each individually assessed and amended by the researchers. Participants were debriefed upon completion of their interviews, and were guided to various helpful links (MIND, Diabetes UK, Beat, CALM) should they have experienced any emotional discomfort during the study.

6.3.4 Reflexivity

As a member of the T1D community, the principal investigator (PI) had their own unique experiences and insight to draw on during the interviews and analytic process. As reflexive thematic analysis encourages subjectivity as a tool during the generation of knowledge and understanding, rather than a barrier, this allowed the PI to attend to the psychologically relevant issues described by participants rather than them needing to spend time explaining various terminology (see Appendix D for longer excerpt).

6.3.5 Data Analysis

Data was analysed using Reflexive Thematic Analysis (Braun & Clarke, 2012). This method of analysis was selected to allow participants a more open environment to discuss the issues they felt were most pertinent to them, as opposed to other methods such as the Framework Method of analysis which is much more highly structured (Gale et al., 2013). All transcripts underwent initial discriminant case analysis by the principal researcher to identify overarching themes which were evidenced in all of the patient experiences and how they may overlap, as well as to highlight between respondent accounts and observe whether these may relate to age of diagnosis or length of condition. Further open-coding analysis of these themes was then conducted on NVivo, a qualitative software package used to facilitate coding and retrieval of the data. Reductionist checklists like the consolidated criteria for reporting qualitative research were avoided during this analysis because of issues such as the unrealistic creation of rationality and objectivity (Buus & Perron, 2020).

6.4 Results and Discussion

The thematic analysis of the interviews resulted in the development of five primary themes: *Complexity and variability of condition management*, *Threats to self-efficacy*, *Impact on mental health*, *Social support*, and *Technological advances*.

6.4.1 Complexity and variability of condition management

Participants all highlighted that the natural complexity and variability that comes with managing T1D was a huge drain on cognitive capacity. Each interviewee, when describing their day-to-day living with the condition, mentioned about having to consider a multitude of factors throughout the day which must be considered if they were to achieve their desired levels of control. These included considerations of work location, as many worked in a hybrid manner and had to adjust their routine depending on whether they were working from home or

commuting to their place of work. Other factors included considerations of work-related requirements during the day, as this would impact their eating habits and BG targets. Every participant alluded to the impact that this then had on feelings of cognitive ability, with HA stating, "*I'm probably tired because I'm doing this a lot and it does affect your health and…yeah it takes a lot of physical and mental energy*".

Relentless cognitive effort required. The overriding message which participants highlighted as part of this sub-theme was that no two days of living with T1D are ever the same, and that the complexity and variability of living with the condition requires constant cognitive attention and effort. Many of the participants, particularly those who were not using closed-looping to manage their condition, described a big part of their normal daily routine as 'micromanaging' their BG levels and assessing whether any adjustments are required. These adjustments could be due to any number of reasons, from a slight deviation in carbohydrate consumption or calculation, to hormonal influence, but is often not known. In *Table 2*, participant HA highlights that the uncertainty of not knowing what her BG is going to do on any given day is difficult to deal with. This highlights the consistent SR drain that is felt by people living with T1D, as the lack of consistency leads to the constant requirement of cognitive involvement.

Although no participants had engaged in insulin omission as a method of weight loss (IO), CL alluded to the fact that she would intentionally avoid reducing her BG for a time when hyperglycaemic, as she were aware that doing so may cause her to lose a small amount of weight,

> "*when I was a bit younger. I would never do it as the sole reason, but if I was running a bit high I'd be thinking 'ohh I'm probably losing a bit weight now', but I wouldn't be like I'm not gonna take anything because I wanna lose weight,*

> *but it kind of make me feel like oh, this is alright. I don't think I would use it and never use it as a weight loss mechanism…it was more like knowing that that was a benefit, although knowing it was bad for my health…I've realised there might be an outcome and I felt like oh that's alright.*"

Particularly stark in this admission was the fact that CL was fully aware of the dangers of engaging in this behaviour, but lacked the motivation necessary to modify their actions. This suggests a deficit in SR, due to a lack of motivation to attain the long-term goal of BG targets, and thus avoiding hyperglycaemia-related complications.

Variability caused by menstrual cycle and menopause. A large amount of the complexity and variability experienced by women with T1D were highlighted to be as a result of either their menstrual cycle, or due to them being perimenopausal. While the hormonal impact that these cycles have on glycaemic variability have only recently begun to be clinically observed, but Brown and colleagues (2015) identified changes to insulin sensitivity across various stages of the menstrual cycle. Within the current study, women reported drastic changes to their typical insulin requirements, with CL reporting that she becomes so insulin resistant during the week of her period that she has to double her calculated doses for meals (see *Table 1*). This variation necessitates women to endure even greater cognitive efforts when managing their BG. The menstrual cycle must first be tracked, before variations in insulin sensitivity must then be observed which will require many months of conscious cognitive effort. For CL, who had lived with T1D for 14 years, she had only just begun to understand the impact that the menstrual cycle has on her BG management: "*it took me years as well to work out what was happening*". GM echoed this, and commented on how her insulin ratios change drastically throughout the month depending on the point of her menstrual cycle,

> "*certain times of the month I can need to be on like a double ratio and then other times of the month I'm on a lower ratio. So that can be a mathematical challenge because it's then like ooh do I need double or am I on a single so that can be a bit of a nightmare.*"

This increased cognitive requirement of the menstrual cycle that women with T1D have to contend with in order to effectively manage their condition may lead to a greater depletion in SR capacity, and thus help explain why women with T1D are more susceptible to conditions associated with reduced SR, such as disordered eating practices, than men (Hall et al., 2021).

6.4.2 Threats to self-efficacy

A common theme among participants was how various aspects of living with T1D impacted their self-efficacy, that is the belief in their capability of managing their condition. As mentioned above, the complex and variable nature of T1D management often leads to deviations in BG control, and these deviations can have a large impact on a person's motivation to assert control over their behaviours. However, aside from the day-to-day variations and their impact, a number of other factors were highlighted as significant threats to participants' feelings of self-efficacy: *Food and eating*, *Social misconceptions of type 1 diabetes*, and *Lack of access to diabetes healthcare services*.

Food and eating. A factor which came up in each of the interviews, difficulties regarding food and eating caused many participants to alter their desired routines and eating habits out of fear of the resulting impact on BG, and the subsequent reduction that this then had on their self-efficacy levels. RF demonstrated how depending on her work routine, she changed her eating habits, "*if I've got something really important on [redacted], this is probably really bad like, but I will choose not to eat until after…[because] I know that it costs*

me on the other side of it". The worry of adverse BG prevents RF from eating, because the consequences of adverse BG would be greater cognitive load to rectify the adversity. This would also then lead to reduced self-efficacy because of the consequence it might have on her important event.

Fear of long-term consequences, however, may serve as a protective factor from the development of these eating habits into disordered eating behaviours such as insulin omission. As HA states, "*I think I'm too afraid somehow to use insulin to try to, to do more than what I should be doing*". Having previously experienced diabetic ketoacidosis (DKA), a potentially fatal state of high BG, and due to the awareness of potential future complications, fear drove some participants to remain motivated and keep attempting to attain good overall control. However, this fear is unlikely to improve levels of self-efficacy.

Social misconceptions of type 1 diabetes. Due to the lack of knowledge surrounding T1D management among the general population, participants found it difficult to manage other people's expectations of them and their condition, and this had a profound impact on their own levels of self-efficacy. HA alluded to how people's lack of understanding of the instability and variability of T1D impacted her mental wellbeing and sense of efficacy, "*you also have to deal with people's expectations. You know, like how come you're feeling this way, you know, no change since yesterday, yesterday you were in great form. Now you're just kind of, you know, a slob*". This additional load on a person with T1D's emotional wellbeing could have a significant impact on their motivation to continue working towards BG management.

Similarly, MG highlighted how being diagnosed in her 30s left her feeling isolated, "*Nobody around me knows what to do or get just how much this impacts on my life and how many times of the day I think about it and have to plan and they just don't understand*". Social isolation, as suggested by the need-to-belong theory (Baumeister, 2012; Baumeister & Leary,

1995) can significantly impact levels of motivation with can subsequently lead to SR failures. These social misconceptions of T1D and the intensity required to manage it may therefore lead individuals to feel isolated and excluded from those around them, which could cause failures in SR and may lead to the development of unhealthy coping mechanisms as a result.

Lack of access to diabetes healthcare services. All participants reported historical difficulty getting an appointment with their diabetes teams, which are practically due to the COVID-19 pandemic and subsequent patient backlogs. RF reported, "*I haven't had a face-to-face appointment since 2019*", while CL stated, "*I haven't had an appointment with my consultant for a year and a half, so my last two have been cancelled*". This lack of availability to their diabetes teams was overwhelmingly reported as one of the main barriers these women were facing in regard to their T1D management as, similar to the previous sub-theme, it left them feeling unsupported and lacking appropriate practical support which left them feeling like they were less able to manage their T1D, thus impacting levels of self-efficacy. While the use of remote consultations may improve access for patients within the current backlog, face-to-face appointments are the 'gold standard' which allow healthcare professionals (HCPs) the opportunity to recognise the psychological issues highlighted (Atherton et al., 2018; Forde et al., 2022; Kilvert et al., 2020).

6.4.3 Impact on mental health

Another consistent theme which was addressed by participants was the impact that living with T1D has on their mental health. The cognitive drain and impact on self-efficacy were both prominent features in reported declines in mental wellbeing, while recognising their impact and allowing for greater self-compassion served as a protective factor from this decline. This

is also particularly significant in regard to SR, as emotional distress has been widely regarded to negatively impact the ability to effectively self-regulate (Baumeister et al., 2007).

Relentlessness leading to burnout. When asked what participants found the most difficult aspect of living with T1D, a common response was the relentlessness that comes from managing the condition. This theme continued throughout the interviews, with CL reporting, "*I'm probably tired because I'm doing this a lot and it does affect your health…and yeah it takes a lot of physical and mental energy*". The consistent drain that T1D has on cognitive capacity and self-efficacy can therefore take its toll, and without intervention can lead to burnout whereby individuals no longer have the capacity to engage with their T1D. This can then lead to a disengagement with aspects of management like carbohydrate counting and insulin calculations, and burnout is significantly associated with increased incidences of DKA and hospitalisation (Abdoli et al., 2021).

Recognising the impact that this relentlessness is having on an individual and employing a level of self-directed empathy and compassion appeared to serve as a protective factor from burnout,, as HA states, "*I try to be kind to myself and just say 'okay well today is not a good day, tomorrow is going to be different', and that does help as well to free up space*." Compassion-focussed therapies may therefore play an important role in promoting self-efficacy in condition management of T1D (Kaelberer & Tanenbaum, 2023).

Negative self-talk. Another important factor which was evident across interviews was the level of negative self-talk associated with T1D and its management. As RF bluntly describes, "*our bodies are just broken*". Research has highlighted that negative self-talk and negative thinking are significantly associated with increased levels of affective distress and lower self-esteem (Ronan & Kendall, 1997; Verplanken et al., 2007), which are associated with a number of mental health conditions including depression, anxiety, and eating disorders

(Agliata & Renk, 2009; Christensen & Haynos, 2020). This frequency of negative self-talk could therefore help understand why such mental health conditions are typically higher among individuals with T1D (Barnard et al., 2006; Bernstein et al., 2013, Hall et al., 2021).

Accepting changes to life path. A further common theme among participants was coming to terms with their diagnosis. Interestingly, many of the participants described their process of accepting their T1D as following many of the stages of grief (Kübler-Ross & Kessler, 2009). Initially upon diagnosis, PM described intense sadness which resulted in her seeking psychological support, "*after I was diagnosed, I came home and just cried, night after night.*" Further to this, BH described bargaining thoughts, "*I wish I could have just one meal when I don't have to worry about how much I'm eating or how much insulin I'm gonna need for it.*" MG also elicited signs of denial, describing an incident during a period of burnout where she fell into DKA and ended up in hospital, "*if I'm in hospital, I don't have to deal with [diabetes]*". LC also described her journey to acceptance of her condition, "*I'm not gonna let it piss me off…I have to accept this, it's not going to change. I don't want to be battling it, cross with it, all of that because it's like, I have to be accepting of this, this is my life now. So I had that attitude which I think has served me well*". This progression to acceptance was also echoed by HA, and after describing her path to acceptance, stated, "*it's grief isn't it*."

These results are among the first to highlight a mourning period which occurs when individuals are diagnosed with T1D, particularly if this diagnosis occurs during adulthood. Acceptance has been highlighted as a protective factor from burnout and reduced impact on mental health. While previous research has demonstrated that family members of newly diagnosed children with T1D often experience the five stages of grief (Lowes & Lyne, 2000), there is no empirical research looking into this phenomenon in those diagnosed as adults. Future research may wish to examine whether newly diagnosed adults with T1D demonstrate the five stages of grief, and whether this specifically impacts their efficacy and perceived

capacity to manage their condition. It may also help advise future intervention development, as grief counselling or resources may be pertinent to provide to newly diagnosed adults with T1D.

6.4.4 Social Support

Levels of social support significantly mediated feelings of capacity and efficacy in managing individuals' T1D. Having others around them who could provide emotional support was stated by participants to have a significant impact on their emotional wellbeing, whereas lack of empathy and compassion regarding the emotional impact of condition management from HCPs was found to be a significant barrier for many.

Type 1 diabetes community. A common theme for many of the individuals interviewed was the importance and the impact that having a community of other T1Ds had, both for emotional support but also to help with practical advice regarding condition management. As HA states, "*to find the Twitter community…it has been like a, a door opening up for me where I've realised oh my god, there are other people like me*". This social inclusion links strongly to the need-to-belong theory of SR (Baumeister, 2012), and demonstrates that this sense of community can protect from feelings of reduced self-efficacy. Similarly, MG highlights the impact that this community can have on enhancing knowledge of T1D management and, therefore subsequently, SR, "*I seem to get more answers from the Twitter community than I do in the medical community because they've either been through it, you know*".

Perhaps pertinent to this sense of community increasing feelings of self-efficacy is the fact that all participants of the current study were recruited through the diabetes community on Twitter. Given that participants were active members of this online community, this would tend

to suggest that they were likely to be more engaged with their condition and therefore willing to participate in the research and share their experiences. The results of this study may therefore not align as closely in individuals with T1D whose relationship with their condition is significantly more negative.

Family. Similar to the T1D community, participants highlighted the impact that family relationships could have on their feelings of self-efficacy towards their condition. BH demonstrated how the support from her husband made her feel able to manage her condition from the point of diagnosis, "*That first night, I cried in my husband's arms. And he's like, says we've got this. We can do this. He set up an Excel spreadsheet with everything that I was eating and everything. And he contacted Diabetes UK, who are really good. Umm, so yeah, I mean, you know, I can't fault the support I've had.*" This concurs with previous research which has highlighted the impact that family support can have on perceived self-efficacy. When examining this impact on an alternative chronic physical health condition, Kara Kaşıkçı and colleagues (2007) demonstrated that family support significantly improved feelings of self-efficacy and levels of self-care among patients. This suggests that interventions designed to improve the knowledge and empathy of family members of newly diagnosed T1Ds may significantly improve future outcomes.

Healthcare professionals. Levels of understanding and empathy from HCPs played a significant part on reported levels of self-efficacy among participants. However, participants consistently alluded to the lack of support they received from their HCPs and the impact that this then had on their mental health and levels of self-efficacy. MG highlighted this lack of emotional support or empathy from her HCPs, "*one year I'd actually dropped my HbA1c but like, I think it was like 10 or 11, so it was quite a big drop for me, I was really, like, proud of myself…not once in the phone call did they say 'ohh, you're doing really well.' It was 'no that's not good enough, you still need to push.*" The importance of language has been identified as a

factor in the development of T1DE, as it can categorise individuals into black and white thinking about their condition management (Partridge et al., 2020). It is therefore pertinent for HCPs to monitor their use of language, and ensure that an understanding and empathic manner is maintained.

6.4.5 Technological advances

Participants varied in regard to their usage of technologies. However, particularly for the two who were utilising a closed-loop insulin pump algorithm, the impact that technology had on their cognitive capacity and overall quality of life were evident. Access to a vast quantity of data consistently did have its drawbacks, though, and this was prominent even among participants who only had access to flash glucose technology.

Reduction in cognitive burden. Highlighted previously was the impact that T1D has on cognitive capacity, due to the complex and variable nature of the condition. Participants using a closed-loop system emphasised how this technology was able to significantly reduce this cognitive load, improving their quality of life and overall level of self-efficacy. HA reports, "*it is really life changing. It can really lighten the burden, you know, in every aspect.*" Technology can therefore mitigate some of the cognitive capacity required to manage T1D, and also improve levels of self-efficacy by reducing periods of high and low BG.

Data burnout. While technology can lead to significant improvements, such is the drain felt by the relentless management of T1D, especially given that technology has now made BG accessible consistently throughout the day, that many participants alluded to the fact that they intentionally take a step back from their management when it was perceived to be having a significant impact on their quality of life, as RF mentions, "*with all the data around me…you could easily get overwhelmed with it.*" This could indicate that there is an innate self-

preservation in play which recognises when self-regulatory stores are becoming too depleted and causes the person to actively disengage with the behaviour(s) which are causing this depletion. The Social Self-Preservation Theory (Dickerson et al., 2004) may help to explain this, whereby if an individual with T1D puts all of their efforts into managing their BG and still (inevitably) has periods of being out of range, this may be perceived as a threat to the self and cause feelings of shame, which can lead to negative cognitive and physiological responses (Dickerson et al., 2004).

Furthermore, having access to technology can also reduce feelings of self-efficacy, as HA describes, "*it's almost like weighing yourself. You feel alright and then you get on the weighing scales and like ohh put on weight because I didn't feel bad about myself until I've weighed…if I'm feeling like it's going OK and I'm feeling good in myself to then see that I'm only 50% time in range or whatever, it's gonna make me feel not good about it.*" This highlights that while technology can largely have a positive impact on reducing cognitive load and improving self-efficacy, the consistent exposure to so much data has the potential to cause the opposite effect.

6.5 Conclusion

This study was interested in understanding the prominent experiences of women with T1D, and explore how these factors impact SR capacity and feelings of self-efficacy. The complex and variable nature of T1D was found to be a drain on cognitive capacity, while the impact of food and social misconceptions were found to be threats to feelings of self-efficacy. The impact that living with T1D has on mental health and wellbeing was a consistent theme throughout the interviews, and a mourning period was identified which can mitigate mental health. Social support was also identified as an important mediator of feelings of self-efficacy, with social

inclusion and empathy identified as protective factors. The impact that technological advances have on SR capacity and self-efficacy were also explored, with their impact on reducing cognitive burden examined, but also how data overload can lead to levels of burnout and reduction in self-efficacy. These factors should be individually explored in future research, where prospective interventions can be examined empirically.

6.6

Table 7

Patient demographics

Pseudonym	Age	Length of diagnosis	Technology utilised
CL	41	14 years	Dexcom & MDI
HA	49	24 years	Dexcom & Medtronic 780G (closed-loop)
MG	37	12 years	Libre 2 & MDI
PM	38	1 year	Libre 2 & MDI
RF	44	26 years	Libre 2 & Omnipod (hybrid closed-loop)
BH	44	4 years	Finger pricks & MDI

6.7

Table 2

Themes, sub-themes, and example quotes

Theme	Sub-theme	Quotes
Complexity and variability of condition management		
	Relentless cognitive effort required	"basically throughout the day I tend to check a lot more now because I've noticed that stress with work and anxiety kind of pushes my levels up, so sometimes I have to make my little adjustments sort of thing. So a lot of the day is mainly micromanaging, like ohh do I need to take insulin?"
		"One day is never the same as the next…and that's why sometimes it's quite difficult because, um, you never know what you're going to get and so you have to deal with that"
	Variability caused by menstrual cycle and menopause	"it's having to like completely switch how you're doing things week, you know, day by day, depending where your period is"

		"a week before I have my period, I become really insulin resistant and it, I do track my periods but it takes me usually a few days, oh, that's happening. So I'm like, why am I running high? Why am I running? And then I'm like, okay, like literally nearly having to double my dose to kind of cover meals"
Threats to self-efficacy		
	Food and eating	"I don't not take my insulin and eat food. I don't, I haven't done that. I'll not eat…I'm not trying to lose weight. I'm not trying to not take my insulin, it's not that. I just can't deal with the burden of it or the complexity of it, cause it's not in, out, and done"
		"I was finding it really difficult to keep within range or, you know, impossible to keep within range, but difficult to keep in any sort of good time in range on my, on my libre. So I did start limiting my carbs"
	Social misconceptions of type 1 diabetes	"you also have to deal with people's expectations. You know, like how come you're feeling this way, you know, no change since yesterday, yesterday you were in great form. Now you're just kind of, you know, a slob [laughs], you know, or you're saying that things are not right etcetera, etcetera. And you have to

		balance the hormones of being premenopausal, you know, so it's, it's really hard, it's really hard."
		"I'm a 38 year old woman, getting this at this point in my life. And I don't wanna diminish, you know, other people's experiences getting it as children because it's completely different, but the difficulty I've had with that is nobody around me knows anything about it. Nobody around me knows what to do or get just how much this impacts on my life and how many times of the day I think about it and have to plan and they just don't understand"
	Lack of access to diabetes healthcare services	"I haven't had an appointment with my consultant for a year and a half, so my last two have been cancelled"
		"I haven't had a face to face appointment since 2019"
		"it's just a phone call every 12 months"
Impact on mental health		

Relentlessness leading to burnout	"over the years I've kind of realised how much head space it takes for me. Um, and part of kind of being, like, a bit anxious and switched on, I think, is definitely linked to that. Being vigilant, the whole time, that kind of what's my body doing, how am I feeling, planning ahead, thinking. And I think I've, yeah, I've kind of been a bit gentler on myself, acknowledging maybe that is, maybe that is a lot to kind of carry."
	"I'm probably tired because I'm doing this a lot and it does effect your health and. Just being a bit gentler with myself about it I think, and understanding that that is something that's on me, and yeah it takes a lot of physical and mental energy"
Negative self-talk	"If I've been high for a while, I'm kind of like [redacted] you need to get like, you need to be more confident with your dosing and be really on it and take more risks of going hypo"
	"I'll give myself a talking to, I think if I've just, I can sort of like see that I've been high too much"
	"our bodies are just broken"

	Accepting changes to life path	"I think I just was always like I'm not gonna let it piss me off. I have to accept, so from the beginning I was always like I have to accept this, it's not going to change. I don't want to be battling it, cross with it, all of that because it's like, I have to be accepting of this, this is my life now. So I had that attitude which I think has served me well"
		"it took some time just to get to grips with it and just to, um, to accept it and I think that's what it is. It's, you know, acceptance is something that, um, you, you get, um, at one point but sadly it's not straight away"
		"I wish I could have just one meal when I don't have to worry about how much I'm eating or how much insulin I'm gonna need for it. I just wanna be able to just eat and not think about it. And sadly those days are gone."
Social support		
	Type 1 diabetes community	"I'm now on the WhatsApp group and it's a really lovely tight little community of people [with type 1 diabetes] and just the very fact that they are all in the same geographical area and they have the same crappy experience of the health service or the same waiting times, it just makes a difference"

Family	“That first night, I cried in my husband's arms. And he's like, says we've got this. We can do this. He set up an Excel spreadsheet with everything that I was eating and everything. And he contacted Diabetes UK, who are really good. Umm, so yeah, I mean, you know, I can't fault the support I've had”
	“I'm lucky because I can just bounce off of my partner and just say oh for Christ sake, what's going on this time sort of thing”
Healthcare professionals	“I don't feel I get enough support from like my diabetes team…literally it was like, their attitude was well we can't do anything anymore, like, you know, it's up to you to manage your diabetes, you know. And I'm like but I don't know how to do it”
	“like a case in point, one year I'd actually dropped my HbA1c but like, I think it was like 10 or 11, so it was quite a big drop for me, I was really, like, proud of myself…not once in the phone call did they say ‘ohh, you're doing really well.’ It was ‘no that's not good enough, you still need to push”

Technological advances	Reduction on cognitive burden	"it's just the freedom. It's like I wouldn't have the job I have unless we had the tech. And if I, I wouldn't have, be as comfortable and getting stuck into my work if I didn't have, if I didn't trust the tech. And, and I didn't, I wouldn't have a, have the freedom I have as a parent even more so to do what I do and trust the tech and the tech can be trusted and does enough"
		"it is really life changing. It can really lighten the burden, you know, in every aspect. You know your line is much improved because for a start you sleep at night"
	Data burnout	"with all the data around me…you could easily get overwhelmed with it"
		"it's almost like weighing yourself. You feel alright and then you get on the weighing scales and like ohh put on weight because I didn't feel bad about myself until I've weighed…if I'm feeling like it's going OK

	and I'm feeling good in myself to then see that I'm only 50% time in range or whatever, it’s gonna make me feel not good about it. So yeah, if I'm honest, I'm a little bit avoidant with it”

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Chapter 7

Self-Regulation and Type 1 Diabetes: Links to Disordered Eating, Condition Management, and Insulin Omission for Weight Loss

Discussion

7.1 Overview

This thesis explored the role of self-regulation (SR), and more specifically how the capacity and motivation to self-regulate impacts disordered eating, condition management, and insulin omission for weight loss (IO) among women with type 1 diabetes (T1D). Rates of T1D and disordered eating (T1DE), in women in particular, have previously been demonstrated as highly prevalent (Doyle et al., 2017). Studies report TIDE is associated with increase in morbidity and mortality and a reduced quality of life compared to those with type 1 diabetes who do not restrict insulin (Peveler et al., 1992) , as it is often associated with an increase in average blood glucose (BG) levels (HbA1c; Nilsson et al., 2020) which can lead to the development of a number of long-term physical health complications including retinopathy, neuropathy, nephropathy, and early mortality (Hall et al., 2021).

Living with T1D necessitates a large amount of daily SR demand. Individuals must consistently monitor their BG, assess the carbohydrate contents of any food they are consuming and calculate an appropriate insulin dosage to be administered. They must be aware of their hormonal state and the impact that deviations can have on insulin sensitivity, and monitor activity levels which could adjust BG levels, to name a few daily considerations. A behaviour exclusive to individuals with T1D, and one which is prominent among people suffering with T1DE, is IO whereby insulin is purposely omitted because the subsequent high BG levels can lead to rapid weight loss. Studies have indicated that rates of IO among individuals with T1D may be as high as 60% (Deiana et al., 2016), and therefore identifying factors which lead to the development of this behaviour is critical in understanding its function, developing future interventions, and reducing long-term complications.

The ability to enact SR is considered essential to success (Calkins, 2007; Moffitt et al., 2011; Vohs & Baumeister, 2011), as it refers to one’s ability to monitor, regulate, and amend

their emotions and behaviours to attain a long-term goal (Nigg, 2017). A body of research has identified deficits in SR among individuals with eating disorders (EDs), including anorexia nervosa (AN; Hatch et al., 2010) and bulimia nervosa (BN; Biberdzic et al., 2021). The purpose of the present thesis was to explore SR among individuals with T1D, and examine whether it plays a role in the development of T1DE, and omission or restriction of insulin.

One prominent theory of SR is the strength model of self-control (Baumeister et al., 2007), which considers SR a finite resource which becomes depleted through use (termed 'ego depletion'). In other words, effortful engagement of SR will result in reduced capacity to enact SR subsequently. Consistent use of SR, through the relentless requirements of managing T1D for instance, could cause chronic depletion of SR resources (Wang et al., 2015) and potentially leave individuals more susceptible to developing disordered behaviours.

Another prominent theory of SR is the self-efficacy theory of motivation. This proposes that individuals who have the belief in themselves to be able to learn and perform effectively have a greater ability to manage their emotions and behaviours (Bandura, 1997; Schunk, 1990). Levels of self-efficacy have been repeatedly demonstrated as predictors of chronic illness management (Chan, 2021; Farley, 2020), with reductions in self-efficacy associated with less adherence to treatment (Curtin et al., 2008) and increased risk of depression (Bandura et al., 1999).

The studies reported in this thesis were therefore designed with the aim of exploring the role of SR deficits in the development of disordered eating, firstly among the general population and then to investigate their relationship in T1DE and IO in women with T1D, to gain a greater understanding about the factors which might be causing these deficits. This initially meant exploring SR among the general population, to identify whether deficits may leave women more susceptible to engaging in disordered eating practices where a tentative

association was found between SR deficits and increased bulimic tendencies. This methodology was continued into the next study where these SR deficits were identified among a population of women with T1D, and T1DE and IO were found to significantly relate to reduced SR. In an attempt to identify whether SR deficits were the consequence of the constant focus on food and carbohydrate counting necessary in T1D, the third experiment employed an implicit association test to examine unconscious bias around food. The main aim was to investigate whether high carbohydrate foods, which arguably demand greater cognitive effort among individuals with T1D and therefore a greater demand on SR, were perceived as more negative. The results did not support this hypothesis, and in fact demonstrated the opposite whereby low carbohydrate foods were associated with a negative implicit bias and greater drain on SR. From this, a qualitative interview study was devised as the fourth experiment, to allow women living with T1D to provide a personal account as to what drives or restricts their condition management and eating behaviours.

Overall, the four studies together showed that deficits in SR are common among women with T1D, and that these deficits drive difficulties in condition management which can lead to T1DE and IO. However, these deficits may not be the result of the constant focus and cognitive demand required by food, as there was no difference on SR scores between T1Ds and controls in the implicit association test. Rather, based on individual accounts of living with the condition, there appears to be a relationship between the general cognitive demand of living with the condition, and the consistent threats to self-efficacy, which can lead to SR failures and disordered eating practices among women with T1D. More specific findings relating to the individual experiments will be discussed in the following sections. Future research and limitations will also be addressed.

7.2 Self-Regulation as a Predictor of Disordered Eating in the General Population

Previous research has suggested that SR deficits are present in a number of EDs (Beadle et al., 2013, Lavender et al., 2015), however there was little to no research exploring SR and its links to disordered eating practices in the general population. The first paper of the thesis (chapter 3) aimed to address this, by examining the role of SR in disordered eating behaviours and body image among women in the general population. It was hypothesised that deficits in SR could be identified as a predictor of the development of disordered eating through standardised questionnaires. Our results provided tentative support for this hypothesis, whereby regression analysis demonstrated that reduced scores on the SR measure (SSRQ) significantly predicted increased disordered eating behaviour (measured on the EAT-26) and reduced body satisfaction (on the BSQ). This association was particularly prominent on the *Bulimia and Food Preoccupation* subscale of the EAT-26 indicating that, among the general population, a lack of perceived control regarding food consumption may leave individuals with SR deficits susceptible to developing bulimia nervosa (BN), as suggested by previous research (Schupak-Neuberg & Nemeroff, 1993; Lavender et al., 2015).

This paper also allowed for a baseline to be produced with regard to the SR levels and disordered eating patterns of individuals without T1D, which could then be drawn upon as a methodologically similar experiment in the second paper.

7.3 Self-Regulation Deficits in Women with Type 1 Diabetes as a Predictor of Type 1 Diabetes and Disordered Eating (T1DE), and Insulin Omission as a Method of Weight Loss (IO)

Relative to the general population explored in the first paper, paper 2 demonstrated that women with T1D were significantly more likely to demonstrate SR deficits. This supported our

hypothesis that the demands of living with T1D causes greater depletions to SR, making individuals more susceptible to subsequent SR failures. This provides evidence in support of a number of SR theories explored in the literature review, including the resource model of self-control (Baumeister et al., 2007). The constant daily demand placed on SR in order for individuals with T1D to effectively manage their BG could lead to this finite SR store becoming chronically depleted, leading to the deficits in SR demonstrated in the second paper.

Alternatively, as explored at greater length in the fourth paper, these deficits in SR may be due to reduced feelings of self-efficacy which consequently reduces motivation to effectively regulate condition management (Bandura, 1997). The self-efficacy of women with T1D has been demonstrated to be influenced by a variety of factors, from unpredictability of BG management causing feelings of struggle, to social misconceptions leading to negative self-perceptions. Based on the principles of social cognitive theory (Bandura, 1986), insufficient self-efficacy would cause individuals with T1D to demonstrate difficulties managing their emotions and behaviours (Schunk, 1990), therefore resulting in SR failures which leave them more susceptible to developing difficulties with their mental health.

While support for a number of theories of SR have been discussed, a full understanding of which most aligns with the deficits found in this research is beyond the scope of the current thesis. Further examining and identifying the social, cognitive, and neurological drivers of these deficits in individuals with T1D should be priority for future researchers.

These deficits in SR among women with T1D were also strongly associated with disordered eating behaviours, especially those measured through the diabetes specific DEPS-R. This demonstrated that as levels of SR reduced, individuals were more likely to engage in T1DE and IO. This provides support for the findings of Grylli and colleagues (2010) who demonstrated a relationship between SR deficits and disordered eating behaviours in

adolescents. However, our research adds to the knowledge base by demonstrating that this relationship is not restricted to adolescents but is also present in adulthood. It also demonstrates this relationship in regard to diabetes-specific behaviours, highlighting the strong link between SR deficits and T1DE. The results presented in paper 2 are also among the first to demonstrate the link between reduced SR and engagement in IO, indicating that the lower SR capacity increases the likelihood to manipulate the insulin regime as a method of losing weight.

The evidence from paper 2 adds to our knowledge about the prevalence of T1DE and IO among women with T1D. In our sample, over 60% of participants scored above the threshold indicative of T1DE behaviours, with 40% also admitting to IO. These results indicate that disturbed eating behaviours are highly prevalent among women with T1D. While research has struggled to quantify rates of EDs across the lifespan of women, the general consensus is that rates are typically higher during adolescence compared to adults (Fulton, 2016). While the present collection of studies did not collect data on prevalence rates of T1DE or IO in adolescents, it is fair to state that the prevalence rates among women with T1D are still starkly high and therefore evidence of such behaviours should be continually watched for long into adulthood.

7.4 Measuring T1DE and IO in Clinical Practice

The second experiment highlighted the disparity which exists between different questionnaires in terms of their sensitivity to diabetes-specific disordered eating behaviours. It was evidenced that the diabetes-specific DEPS-R questionnaire was far more sensitive to disordered eating practices in women with T1D than the more generic EAT-26 questionnaire. Indeed it led to the identification of and additional 40% of participants who exceeded the cut-off score to indicate T1DE. This disparity could hold great significance in clinical practice. Screening for EDs is recommended in diabetes clinics during pre-adolescence, and continue through late

adolescence and into early adulthood (Hanlan et al., 2013), with researchers acknowledging the upmost importance of screening early and often. However, there is currently significant reluctance among clinicians to routinely screen for T1DE and IO, which appears to be largely driven by a lack of confidence among HCPs in identifying and managing the care of such patients (Brewster et al., 2020). Given the number of positive DEPS-R scores seen within the current research, it is imperative that T1DE become a more routine aspect of T1D care. Within this, our research demonstrates that the DEPS-R should be utilised as the preferred screening questionnaire, to ensure that individuals with T1DE are not missed because of lack of sensitivity of more generic screening methods. However, as previously noted, the DEPS-R is not holistic in terms of capturing all disordered eating behaviours and should therefore be used as an initial screen which can be followed up by further clinical assessment.

7.5 Food and Carbohydrate Counting and Links to Self-Regulation

Given the deficits in SR and their association to T1DE and IO found in paper 2, paper 3 looked to examine whether these deficits were associated with food and carbohydrate counting. As the SR demands of continuous carbohydrate counting necessary to maintain BG control are high and constant, it was hypothesised that negative implicit relationships may have been developed among women with T1D towards high carbohydrate foods as they require greater insulin adjustment and therefore potentially SR resources. Our results from paper 3, however, demonstrated no negative bias towards high carbohydrate food. Indeed, high carbohydrate foods were actually seen as more desirable, perhaps because many individuals with T1D often deprive themselves of these foods in an effort to protect from adverse effects on BG. In this case, and as was demonstrated with the results, greater SR demands were linked to low

carbohydrate foods, perhaps because of the restraint necessary to avoid the more desirable high carbohydrate foods (Herman & Polivy, 1984).

7.6 Social Support as a Protective Factor of SR

Paper 4 sought to gain a greater understanding of women's lived experiences of managing T1D on a daily basis, and to identify factors relating to the deficits in SR identified in previous experiments. While a number of factors were identified which served to reduce SR, from the interviews conducted in paper 4 the role of social support in promoting self-efficacy was a consistent theme. High levels of support from family and friends promoted feelings of capability and control, whereas low levels of support mediated negative self-talk and a reduction in self-efficacy. These findings of the impact that a positive social network can have on feelings of self-efficacy and their resulting impact on ability to enact SR support the work previously conducted by Farley & Kim-Spoon (2014) who suggested that social connections have a strong impact on the development of SR during adolescence, and demonstrate that these connections continue to play a defining role in SR into adulthood. These findings therefore highlight that, among women with T1D, having supportive social networks can serve as a protective factor to SR depletion. Conversely, however, a lack of social support can lead to a reduction in self-efficacy and subsequent difficulties enacting SR, which, based on the results of paper 2, may leave individuals more susceptible to developing T1DE and IO. Future research should consider how families and friends can best be supported to offer support to those living with T1DE.

7.7 Technological Advances and Self-Regulation

Technological advances in diabetes medicine are leading to a whole new area of research into T1D. As evidenced in paper 4, technology has the potential of largely reducing the burden previously felt by the daily demands of managing the condition. This supports a recent study which found that, among participants who were using closed-loop automated insulin delivery, the biggest benefit felt was the reduction in mental and behavioural burden (Suttiratana et al., 2022). This reduction in mental burden could lead to a reduction in SR burden. However, as highlighted in paper 4, the constant accessibility to BG readings and trends can have the potential to cause burnout, whereby an individual no longer feels able to process the levels of data they are exposed to. This phenomenon appears to be a novel finding, but links well to the research examining alarm fatigue which is seen often among people with flash or continuous glucose monitoring (CGM) technologies (Shivers et al., 2013).

There are a number of unknowns regarding the development of new technologies for people with T1D and the impact these may have on SR. CGM allows individuals to observe patterns in BG levels which would be difficult to recognise using older methods, and may therefore lead to better BG management and increased feelings of self-efficacy regarding condition management. Conversely, however, this constant availability of data could cause a reduction in self-efficacy if BG levels are not within an individual's preferred range. Further research is necessary to understand the impact that these new technologies are having on SR, and moreover to examine the impact this has on T1D management and development of T1DE and IO.

7.8 Further Considerations

The aim of this thesis was not to evaluate the fit of different behavioural models of SR to those living with T1D, but rather aimed to further our understanding of the relationship between SR

related and condition management and disordered eating behaviours among women with T1D. However, based on the findings presented it could be argued that a number of these theories of SR, combined, may help explain the development and maintenance of T1DE and IO. For example, based on the restraint theory proposed by Herman & Polivy (1984), and as presented in paper 4, individuals with T1D have to enact a high level of cognitive control over their eating on a day-to-day basis in order to maintain BG levels. This may make individuals more susceptible to overeating if the high levels of cognitive control cannot be maintained. Over time, such overconsumption of food and drinks can lead to weight gain, which in turn can lead to behaviours to control their weight (although it ought to be mentioned that some extraneous factors within T1D such as overtreatment of hypos, fear of exercise, and insulin being a growth hormone, may also contribute to such weight gain). The deficits in SR observed within our studies, based on the theory of 'ego depletion' (Baumeister et al., 2007) and self-efficacy theory (Bandura, 1997) may help explain why individuals are unable to lose weight in a healthy manner, and instead turn to disordered eating behaviours as a method of weight loss, such as T1DE and IO. The isolation that comes with living with T1D, based on the need-to-belong theory (Baumeister, 2012), also leaves these individuals unable to find the necessary motivation to enact SR to improve diabetes management and stop IO. This can lead to a vicious cycle of T1DE which is difficult to recover from, given that SR does not get chance to replenish because of the daily demand which comes from living with T1D.

Worth noting is that in paper 4, while all participants mentioned changing their eating habits in similar ways, none of them reported any difficulties with T1DE or IO. This could be due to the fact that all participants were diagnosed with T1D at age 18 or older, meaning they were adults when diagnosed. Previous research has indicated that girls diagnosed with T1D between the ages of 7 and 18 years old were significantly more likely to develop a severe eating disorder (Takii et al., 2011). This could therefore suggest that age of diagnosis may serve as a

protective factor in the development of T1DE and IO, as SR has already had the opportunity to fully mature prior to diagnosis and as such has not been subjected to depletions or deficits during its development. While impossible to predict, it is of interest whether any of the reported eating habits mentioned in paper 4 would have led to the development of T1DE had participants been diagnosed at a younger age.

7.9 Future Research

A body of evidence, based on the theory of resource allocation (Beedie & Lane, 2012), suggests that glucose is a resource that may fuel SR. This could suggest that, depending on an individual's BG levels at the time of completing one of the studies, their SR scores could have been affected. Future research may wish to examine fluctuations in BG and its impact on perceived SR in individuals with T1D, which would allow the aforementioned theory to be assessed. This should also be taken into account when conducting future research, as it may influence results examining SR in a population of people with T1D.

Moreover, the experiments presented in the current thesis only provide a snapshot of SR at a single point in time. Longitudinal designs have been utilised to examine SR across an extended time period in other areas of psychological research such as academia (Nota et al., 2004) and exercise (Oaten & Cheng, 2006), so engaging similar methodology to explore SR longitudinally among individuals with T1D could help provide a clearer picture as to whether age of diagnosis or length of time living with the condition impacts SR levels.

Highlighted in experiment 4 was the impact that technology played on reducing mental load, and thus alleviating the demand on SR. However, it was also noted that data overload can cause individuals to disengage, as the constant exposure to BG readings, particularly, could cause a threat to feelings of self-efficacy. As diabetes technology continues to progress and

advance, future research needs to assess the impact of these new integrations to T1D management on mental health and wellbeing.

Furthermore, beyond the scope of the current thesis was to compare populations of individuals utilising different methods of diabetes management. Based on our findings, the reduction in cognitive load associated with insulin pump use would suggest that among these individuals there would be a lesser reduction in SR than in individuals using MDI. However, there is currently no research exploring this. Future studies could examine the impact that various methods of management of T1D have on SR, and explore the impact that these technologies may play on the development or maintenance of T1DE and IO. Such research will help to advise policies such as the NICE guidelines, and therefore improve accessibility to technology throughout NHS Trusts.

7.10 Limitations

Weaknesses within each experimental study have been discussed as appropriate in the relevant discussion sections of their chapter. However, further constraints which ought to be highlighted are addressed below.

A major limitation to this thesis was the role of the COVID-19 pandemic. The initial proposed experiments intended to examining SR within an adolescent T1D population, utilising methodologies such as eye-tracking. The first 6 months of the PhD were therefore focussed on designing a collection of studies suitable for an adolescent population, and coordinating with NHS Trusts and school partners to identify and secure avenues of recruitment. Once the pandemic hit, this work became void as these avenues of recruitment were no longer viable, and therefore testing the adolescent population became unfeasible. A significant amount of time therefore had to be spent redesigning the research questions of the

thesis, while the levels of uncertainty around the length of lockdowns made it difficult to conceptualise alternative research studies. Given this level of uncertainty, and to ensure that novel data was still collected, all of the studies completed as part of the thesis were designed to be completed online.

Completing research online presents further limitations to be considered. Firstly, and particularly with the first three quantitative experiments where recruitment was largely completed through the Prolific platform, participant motivation must be considered and as such the level of effort and meaningful responses provided. Online research also presents the challenge of potential bots and fake profiles attempting to complete research for monetary gain. To account for this, throughout the studies quantifiers of engagement were included in the form of attention checks, whereby any data that did not meet those checks was omitted from the analysis. However, it ought to be noted that this does not guarantee truthful participant responses throughout the rest of the study. Online research is also susceptible to confirmation bias (Klayman, 1995), but given the nature of the restrictions to recruitment this was somewhat unavoidable.

Also of note, given the ethical restrictions put into place as a result of the pandemic, only very limited demographic data was collected about participants. As such, a number of potentially useful pieces of information were not able to be collected which could have impacted the results of the quantitative studies conducted. It is strongly recommended that future research consider collecting clinical information such as the presence of any comorbid conditions like coeliac disease, which may further increase the risk of disordered eating (Tokatly Latzer et al., 2018), as well as demographics such as ethnicity as evidence suggests that South Asian individuals, for example, are less likely to accept visible diabetes technology due to fear of stigma (Capistrant et al., 2019).

Furthermore, the qualitative interviews conducted are also susceptible to social desirability bias, whereby the participant may struggle to disclose any information which would present them in a less than favourable light. The design of the semi-structured interview schedule was developed to minimise this effect, but its role in participant disclosures ought still to be noted. Given my own personal experiences of living with T1D, during the transcription and analysis of these interviews I was highly aware of my own researcher bias and subjectivity, which is why I ensured that the analysis was independently examined by an impartial colleague.

It ought also to be addressed that the individuals with T1D who participated in each of the experimental studies were likely to be more engaged with and have a more positive view of their condition, which could have had the potential to skew findings. It is well established that involving individuals with T1D in the co-design of research and behaviour interventions can lead to better outcomes (O'Hara et al., 2017), but the challenge for researchers is reaching those individuals who struggle to engage with their condition and, as such, research relating to it.

7.11 Conclusion

In summary, this thesis has addressed a gap in the literature by exploring the role of self-regulation on disordered eating, condition management, and insulin omission for weight loss in women with type 1 diabetes. A number of theories of SR, such as the strength model of self-control (Baumeister et al., 2007), self-efficacy theory (Bandura, 1997), and the need-to-belong model (Baumeister, 2012) have been examined. The pertinence of SR to understanding T1D management, T1DE, and IO has been explored, with deficits in SR shown to increase the risk of T1DE and IO. Moreover, important implications for clinical practice have been highlighted,

whereby the effectiveness of different methodological approaches to assessing T1DE have been addressed.

While this thesis has highlighted SR deficits in women with T1D, and demonstrated a link between these deficits, T1DE, and IO, this theoretical understanding must now be translated into behavioural interventions intended to increase feelings of self-efficacy and self-control. These interventions can then be studied and assessed so that deficits in SR among women with T1D are reduced, and therefore quality of life improved.

Chapter 8

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Appendix A

A Review of Risk Factors Associated with Insulin Omission for Weight Loss in Type 1 Diabetes

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Abstract

Research suggests that as many as 60% of people with type 1 diabetes (T1D) admit to misusing insulin. Insulin omission (IO) for the purpose of weight loss, often referred to as diabulimia, is a behaviour becoming increasingly recognised, not least since prolonged engagement can lead to serious vascular complications and mortality.

Several risk factors appear to be relevant to the development of IO, most notably; gender, anxiety and depression, and increased weight concerns and body dissatisfaction. Evidence suggests that women, especially young girls, are more likely to omit insulin as a method of weight loss compared to men. Mental health conditions such as anxiety and depression are increasingly prevalent in people with T1D compared to their peers, and appear to contribute to the risk of IO. Increased weight concerns and body dissatisfaction are further prominent risk factors, especially given increases in weight which often occur following diagnosis, and the monitoring of weight by diabetes teams.

This review presents evidence examining these risk factors which increase the likelihood of a person with T1D engaging in IO, and highlights the complications associated with prolongment of the behaviour. Further research looking at the comorbidities of these risk factors, alongside other factors, would provide greater insight into understanding IO in people with T1D.

Keywords: type 1 diabetes, diabulimia, IO, gender, mental health, anxiety, depression, weight concern, body dissatisfaction, eating disorder.

Introduction

Type 1 diabetes (T1D) is a condition which effects approximately 400,000 people in the UK alone, including 30,000 children (Diabetes UK, 2016). Type 1 diabetes is an autoimmune disease resulting in the destruction of insulin secreting β-cells within the pancreas (Todd, 2010). Insulin is no longer available to enable the cellular removal of glucose from the blood stream, leading to rising glucose levels and resulting in hyperglycaemia (high blood sugar).

As a consequence of hyperglycaemia, profound changes in energy metabolism occur, resulting in a catabolic condition with "severe depletion of both energy stores and protein mass" (Hebert & Nair, 2010). This insulin deficient state leads to weight loss, as the body is forced to break down fatty acids to maintain normal muscle and other tissue functions. This breakdown of fatty acids leads to the unregulated accumulation of ketones (an acidic by-product of fatty acid breakdown) in the bloodstream. If maintained for even a relatively short period of time (even as little as a few days), high ketone levels can lead to a highly critical state known as diabetic ketoacidosis (Misra & Oliver, 2015). Diabetic ketoacidosis can be lethal, with mortality rates of up to 30% among those admitted to hospital (Oschatz et al., 1999); furthermore, these rates increase even further amongst young children (Edge et al., 1999).

Insulin omission (IO) is a behaviour engaged in by people with T1D. Research suggests that it may be as a method of weight loss (Polonsky et al., 1994). Short term symptoms of IO are those of hyperglycaemia; excessively high blood glucose (>11%), increased ketone levels, thirst, frequent urination, fatigue, and cognitive deficits such as lack of concentration (Ruth-Sahd et al., 2009). The longer and more frequent the IO, and the longer the hyperglycaemic state persists, the more severe the symptoms; weight loss, severe dehydration, and increased glycosylated haemoglobin (HbA1c). HbA1c relates to the average plasma glucose concentration over a three-month period and is therefore a good indicator of blood glucose

levels within that period. Persistent IO therefore leads to prolonged periods of hyperglycaemia and increased HbA1c, which can lead to the increased development of a number of vascular complications (Calcutt et al., 2009) and increased risk of mortality (Goebel-Fabbri et al., 2008).

Prevalence rates of IO vary widely depending on the methodology used, but studies using the Diabetes Eating Problem Survey-Revised (DEPS-R; Markowitz et al., 2010), a questionnaire considered one of the most psychometrically robust methods currently available in assessing insulin manipulation, have reported prevalence as high as 60.2% in a sample of individuals with T1D aged 13 to 55 (Deiana et al., 2016). Rates of IO among children and adolescents with T1D are currently somewhat unclear, perhaps partly because young people are often reluctant to disclose issues with their diabetes teams (Candler et al., 2018). However, the use of IO as a weight control has been reported in 2% of preadolescent girls (Colton et al., 2004), and 11-15% in adolescent girls (Jones et al., 2000). Furthermore, case studies of young people with T1D, girls in particular, are beginning to emerge (e.g. Kınık et al., 2017), suggesting that persistent IO for the purpose of weight loss is a prevalent behaviour among children and adolescents, as well as adults. A number of the risk factors of IO explored in this review are also seen as having greater prevalence among young people, suggesting that children and young people who have T1D, alongside one or more of these risk factors, will be at significant risk of engaging in IO as a weight loss method.

Methods

The authors prepared this review from literature searches in Science Direct, PsychINFO, PubMed, and Google Scholar. After reviewing the available literature relating to diabulimia, IO, and T1D, we identified the following factors as posing the most significant risk to the development of IO related behaviour: gender, the presence of anxiety and depression, and

weight concern and body dissatisfaction. Each of these risk factors will be explored in relation to the development of IO below.

Gender

Gender is well referenced as a significant factor in the development of several mental health conditions, with women and young girls being more susceptible to developing conditions including depression, anxiety, and eating disorders. Research illustrates a lifetime prevalence of generalised anxiety disorder of 7.7% among women, compared to 4.6% in men (Kessler et al., 2012). Similarly, rates of depression have been demonstrated as high as 21.3% women, compared to 12.7% of men (Kessler et al., 1993). Among adolescents with T1D, research suggests that prevalence rates of depression are higher in girls than boys, and that depression in girls predicts poorer T1D treatment adherence (Korbel et al., 2007).

Gender differences also appear prevalent in eating disorders (EDs); overall prevalence rates among adolescents have been demonstrated at 20.8% in girls, and 14.9% in boys (Sepulveda et al., 2008). Girls as young as 10 years old are also significantly more likely than boys to perceive themselves as being a larger size than they are (Thompson et al., 2003), more likely to report lower levels of body satisfaction (Strong et al., 2000), and more likely to display weight concern (Calzo et al., 2012).

Rates of disordered eating behaviours among females with T1D have been shown to range between 30-40% compared to between 9-11% in males (e.g. Baechle et al., 2014). Given IO's utilisation as a weight loss technique, and drive for thinness being a critical element of ED diagnosis (Garner, 2004), it is logical that a number of research papers have highlighted that the number of females with T1D engaging in IO appears to be substantially higher than males. Neumark-Sztainer and colleagues (2002) found that among their sample, 10.3% of adolescent females admitted to IO (7.4% did so to lose weight), compared to just 1.4% of

adolescent males. This is supported by Jancin (2010), who found a female to male ratio of IO of 10:1. However, a recent population-based study has suggested that this difference between genders may not be as great as earlier thought, with rates of female and male insulin restriction at 20.5% and 18.5% respectively (Baechle et al., 2014). Unlike the 2002 study, which required participants to have been diagnosed with T1D for at least 1 year, Baechle and colleagues' study included participants with early onset of T1D (diagnosis between 0-4 years of age). This variation in results could suggest that prevalence rates of IO between genders may differ depending on age of diagnosis, though further research is necessary to support this.

Interpreting these gender differences in rates of IO should be done with caution, as one study suggests that boys with body issues are more likely to overexercise as a weight loss method, rather than restrict their diet (Ricciardelli & McCabe, 2004). This would not always be implicated as disordered behaviour in T1D using traditional questionnaires like the DEPS-R, but could result in IO as a weight loss method. Furthermore, research indicates that males ED sufferers often do not seek out help until their illness becomes severe (Dearden & Mulgrew, 2013), and only 15% of men with an ED will seek treatment (Freeman, 2005), therefore skewing perceptions of gender bias in eating disorders and associated behaviours like IO. However, within a sample of both male and female participants who engaged in IO as a method of weight loss, females were found to have significantly higher HbA1c than males, indicating that they engaged in the behaviour more frequently or for more prolonged periods of time (Deiana et al., 2016); suggesting that females are at a higher risk of developing more significant long-term consequences as a result of IO.

Anxiety and Depression

A number of mental health conditions have been found to have higher prevalence among people with T1D compared to their peers, particularly anxiety and depression. Prevalence rates of anxiety are vastly higher in people with T1D compared to the general population; between 14%-21% and 6% respectively (Bernstein et al., 2013; McManus et al., 2016). While there is currently little research looking at the association between anxiety and IO, higher levels of HbA1c have been found in people with T1D and comorbid anxiety (Shaban et al., 2006), which could indicate engagement in insulin omitting behaviours. Further research looking at this comorbidity is necessary to draw causality.

With regards to depression, a systematic review found an almost 4-fold increase of depression in T1D compared with controls (12.0% vs 3.2% respectively; Barnard et al., 2006). Due to the debilitating nature of depression, everyday behaviours like exercise, maintaining a healthy diet, and managing physical illnesses can become more difficult (Lin et al., 2004). Comorbidity of depression and T1D has been found to associate with less adherence to treatment (Gonzalez et al., 2008) and higher HbA1c (van Tilburg et al., 2001). This comorbidity has recently been shown as bi-directional, where higher depressive feelings lead to poorer diabetes management, and poorer diabetes management cause increased depression (Nouwen et al., 2019). While there is limiting causal research implying the direct effect of depression on engagement in IO, one study of 9-13 year old girls (Olmsted et al., 2008) highlighted that those who admitted to IO scored positively on the Children's Depression Inventory (Kovacs, 1970). However, the issue of causality is difficult. Even in children and adolescents, depression has demonstrated distinct comorbidity with EDs (Swanson et al., 2011), and levels of depressive symptoms have been shown to improve following weight gain in hospitalised eating disorder patients (Sala et al., 2011). Depressive symptoms may also be experienced in patients engaging in IO, given that resulting hyperglycaemia is associated with

low energy levels, poor sleep and trouble concentrating (Ruth-Saad et al., 2009). Future research is necessary to further explore the causal relationship of depression on IO.

Increased Weight Concern & Body Dissatisfaction

Weight concern and body image issues are common among women (Wardle & Johnson, 2002) and increasingly recognised among men (Thompson, 2017); this is often evident from childhood and adolescence. A study of 1515 children aged 9-14 years of age reported high levels of body dissatisfaction: 50.5% of girls and 35.9% of boys wanted a thinner body shape, while 7.2% of girls and 21.1% of boys wanted a larger shape (Dion et al., 2016).

The early emergence of body dissatisfaction has unsurprisingly been linked to the development of EDs, including anorexia nervosa (Button & Whitehouse, 1981) and bulimia nervosa (Watson et al., 2011), in childhood and adolescence. The frequency of EDs varies widely across age and gender, but Stice and Bohon (2012) report an overall lifetime prevalence of anorexia between 0.9-2.0% for women, and 0.1-0.3% for men, and a lifetime prevalence of bulimia between 0.2-3.5% for women and 0.9-2.0% for men. Evidence of increased prevalence among children is also beginning to emerge, with rates of bulimia among youth as high as 2% (Merikangas et al., 2010).

In addition to the common factors listed above, patients with T1D face two additional challenges, and may experience negative associations with their body shapes as early as diagnosis. First, prior to diagnosis many individuals with T1D experience substantial weight loss, due to the hyperglycaemic state caused by insufficient insulin production. Once diagnosed and upon the commencement of an insulin regime, patients will start gaining weight as their body regains the fluids it needs and rebuilds its fat stores. This weight gain sometimes exceeds pre-T1D levels, and a high proportion of individuals become overweight or obese (Newfield et

al., 2009). This noticeable, and sometimes sudden, weight change can cause serious concern in patients with T1D, and is often attributed to the use of insulin (Larger, 2005). With the average age of diagnosis being between 10 and 14 years old (Diabetes UK, 2010), children and adolescents with T1D may begin to experience body shape and weight issues earlier compared to their peers.

Secondly, following diagnosis, weight is regularly monitored and reviewed in the management of T1D. Body mass index is one of eight care process checks recommended by The National Institute for Health and Care Excellence (2015), meaning patients are routinely weighed during their regular medical check-ups. The constant weight checks, along with the forced dietary monitoring required to adequately control blood glucose, can create additional negative associations between body size and eating behaviours in patients with T1D. This in turn may then also lead to the development of further weight concerns, body dissatisfaction eating disorder related behaviours. Cumulatively these factors are surmised to be influential in the development of EDs.

There may be merit in changing diabetes clinical practice to reduce these two additional challenges that children and adolescents with T1D face. For example, young patients and their families could be reassured by their diabetes team about the way the human body temporarily overshoots after a period of hyperglycaemic (starvation) state, such as that which occurs at the onset of diabetes. In addition, clinicians could explain expected weight and height increases during normal growth and puberty, and can encourage more positive blood glucose management methods, such as moderate physical activity and dietary plans, that do not place so much emphasis on patients' weight itself. Providing the patient and their family with sufficient education at the point of diagnosis is the key to success (Acerini et al., 2014).

A meta-analysis suggests that individuals with T1D are up to three times more likely to suffer with an ED than their peers (Young et al., 2013). Furthermore, cross-sectional research suggest that rates of insulin misuse is increased among patients with T1D where an ED also co-exists (Nielsen, 2002), suggesting a close link between T1D mismanagements and disordered eating behaviours. Peveler et al. (2005) reported that weight concern and body dissatisfaction also play an important role in the development of insulin misuse in children and adolescents, as well as in adults. While not all incidences of IO are related to an eating disorder diagnosis (see 'Other Functions of IO'), rates of IO among individuals with T1D and comorbid ED are significantly elevated, therefore suggesting the significance of weight concern and body dissatisfaction as risk factors in the development of IO.

Complications Associated with Prolonged IO

IO causes hyperglycaemia, which can lead to several vascular complications associated with increased morbidity and mortality (Goebel-Fabbri et al., 2008). Understanding the risk factors associated with developing the behaviour is therefore crucial in reducing the likelihood of developing the below complications.

Retinopathy. Prolonged hyperglycaemia can lead to the formation of microaneurysms in the retina, which can cause occluded vision and eventually lead to blindness (Donaghue et al., 2018). This is associated with significant reduction in quality of life (Brown et al., 2002) and increased mortality (Kramer et al., 2011). Nielsen (2002) found that retinopathy took, on average, just 3.4 years to develop in patients who engaged in IO, compared to 11.5 years in those with T1D but without IO.

Neuropathy. Persistent hyperglycaemia can lead to nerve damage, which reduces vascular flow and can result in amputation (Ziegler et al., 1988). The 3-year survival rate in

diabetic patients with neuropathy complications has been found at less than 17% (Ramsey et al., 1999). Cases of neuropathy are also disproportionately found in those who omit insulin; Steel and colleagues (1987) found that of the 9 participants in their sample who admitted to IO, 5 (55.5%) displayed symptoms of neuropathy.

Nephropathy. Lengthy periods of hyperglycaemia can result in structural damage to the kidneys, causing reduced function and eventual kidney failure (Donaghue et al., 2018). Diabetic nephropathy is generally accepted as the leading cause of mortality among patients with T1D, with lifetime incidence rates of approximately 50% (Marshall, 2012). This is particularly significant given recent longitudinal evidence illustrating a mortality rate due to nephropathy of 32.8% (Ang et al., 2014).

Cerebral oedema. The rapid change of extracellular brain fluid caused by rapid correction of hyperglycaemia can lead to significant complications (Varela et al., 2018). Cerebral oedema is recognised as one of the most dangerous complications of hyperglycaemia, with a mortality risk of 20-25%; it is also considered to account for 60-90% of deaths during diabetic ketoacidosis (Wolfsdorf et al., 2006; Rosenbloom, 2010).

Diabetic Ketoacidosis and mortality. Severe dehydration and loss of electrolytes caused by acidosis can quickly lead to coma and death. The mortality rate associated with diabetic ketoacidosis in hospital admissions has been displayed at 13% (Efstathiou et al., 2002). Engaging in IO increases the risk of developing all of these complications associated with hyperglycaemia, which in turn can lead to early mortality.

Other Functions of IO

While the function of IO has been found to be for weight loss purposes in around half of instances (Polonsky et al., 1994), it is important to acknowledge other functions of the

behaviour. One example is the use of IO as a form of self-harm. “Taking too little medication” is a method of self-harm listed the Ottawa Self-Injury Index (Nixon et al., 2002), and given the resulting negative physiological impact which results from IO, the behaviour could be classed as a form of self-injury. Support for this was found in one study where self-destructive behaviour was stated as the cause of 28% of IO cases, compared to weight loss which only accounted for 15.5% (Schober et al., 2011). While the available literature is still limited, there is more evidence emerging illustrating the use of IO as a form of deliberate self-harm (e.g. Staite et al., 2018).

Other prevalent causes of IO include injection anxiety, particularly in children (Young-Hyman et al., 2016), and fear of hypoglycaemia (low blood sugar; Wild et al., 2007). Diabetes burnout, a state of exhaustion towards the condition associated with lack of treatment adherence and deficient blood glucose control (Young-Hyman et al., 2016), may also result in omission of insulin. In this instance, people with T1D report feeling both physically and mentally tired of the constant need for self-care (Abdoli et al., 2020), and are therefore unable to manage their diabetes control as adequately as is necessary. If there is no associated desire to lose weight, then diabetes burnout could be considered an alternative function of IO.

Given the multifaceted nature of T1D and its associated physiological and psychological impact, the function of IO will vary widely and may serve more than one purpose. Therefore, as clinicians become more aware of IO, it is important to consider a number of factors before determining its function, taking into account the complex nature of IO may mean that its functions could change over time.

Conclusions

This literature review illustrates that gender, anxiety and depression, and increased weight concern and body dissatisfaction may all represent significant risk factors in the development of IO. As has been highlighted, a number of these factors have also been demonstrated as having distinct comorbidities. Comorbidity of two or more of these factors may therefore present an even greater risk of engaging in IO behaviours, although there is currently little research to support this.

IO is an extremely complex behaviour, and while the list of factors presented in this paper were selected based on the research evidence suggesting their association with the development of the behaviour, it does not attempt to be exhaustive. Several further factors have been identified within the literature as risk factors to the development of the behaviour. These include family conflict (Vaid et al., 2018), media influence (Hackman, 2015), and socioeconomic status (Hassan et al., 2006), and self-regulatory capacity (Lansing & Berg, 2014). Researchers should take such factors into account before drawing conclusions based on their data.

The importance of expanding this research field cannot be understated, given the dangerous complications associated with the prolonged hyperglycaemia caused by IO, and the research indicating that it is a behaviour which not only affects adults, but children and adolescents as well. Further research may wish to consider the comorbid relationships between the risk factors presented in this paper, to develop a clearer understanding of how and to what extent each of these factors increase the risk of engaging in IO among children and adolescents with T1D.

Declaration of Conflicting Interest

The authors declare that there is no conflict of interest.

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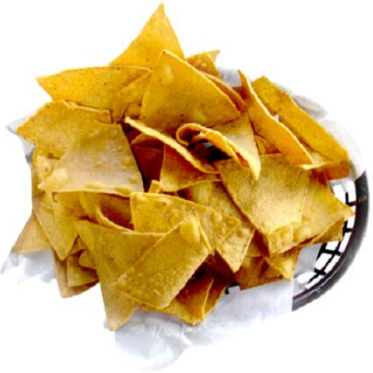
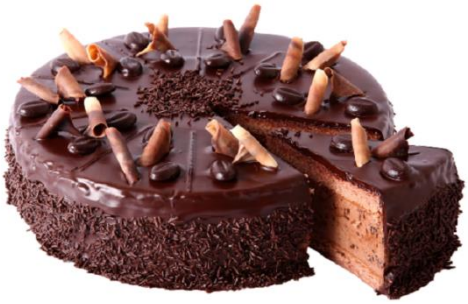
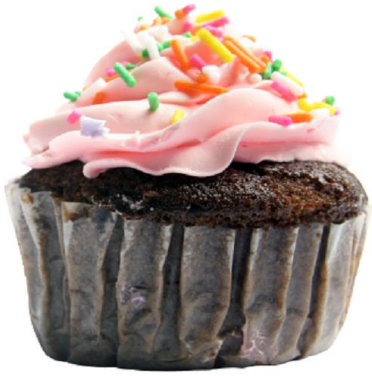
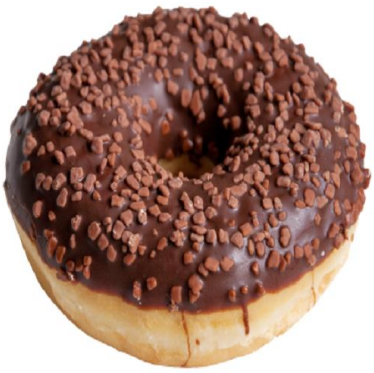
Appendix B

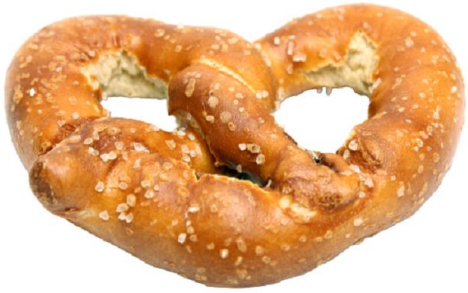
High Carbohydrate/Healthy

High Carbohydrate/Unhealthy

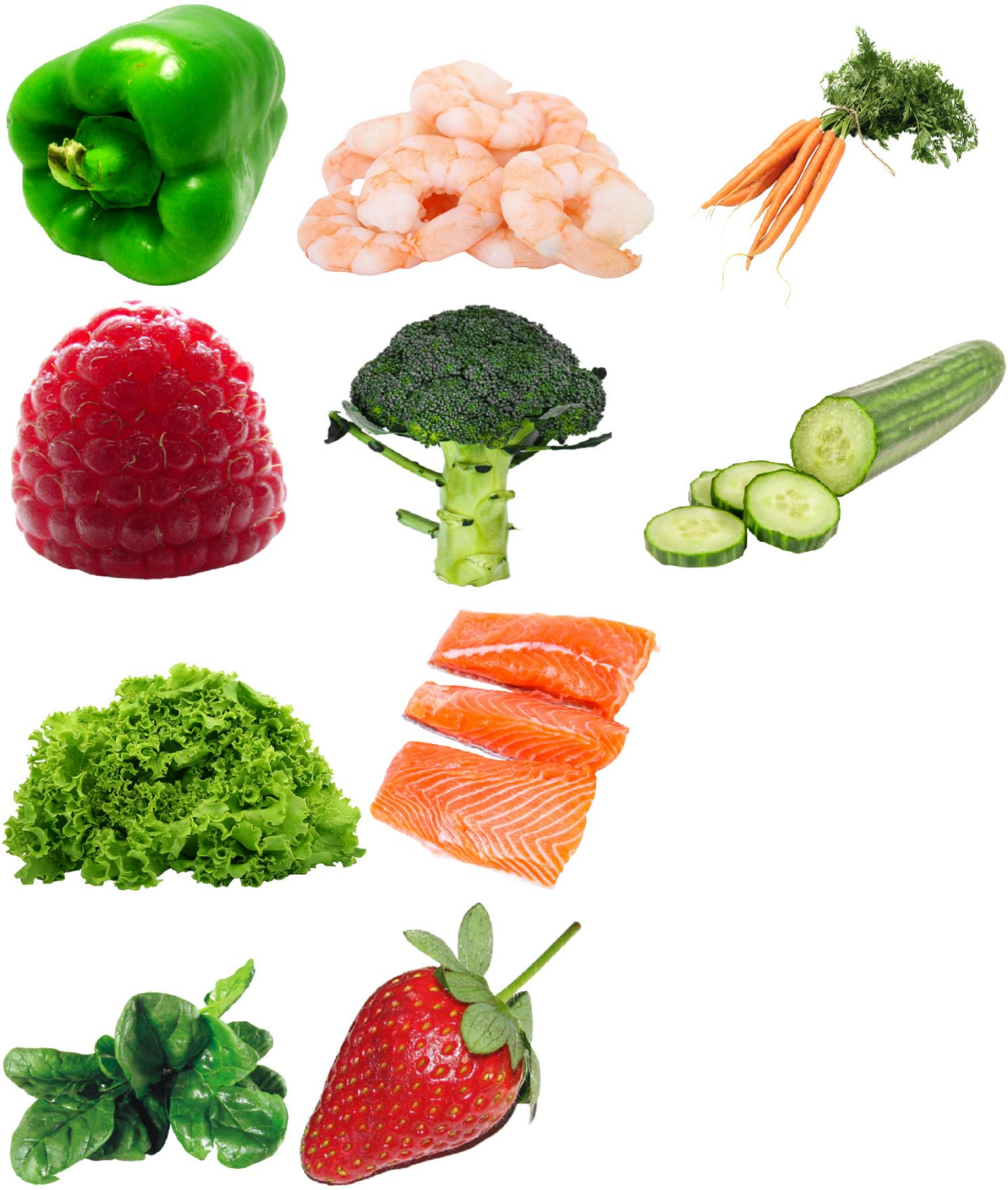







Low Carbohydrate/Healthy



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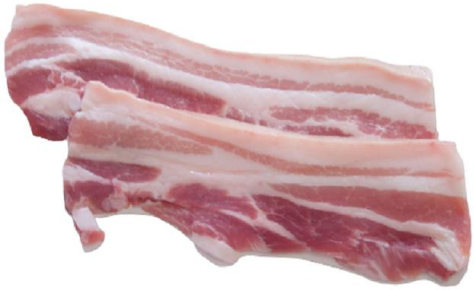

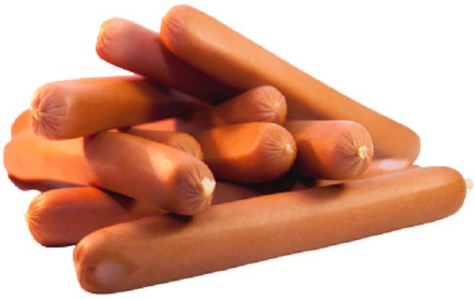


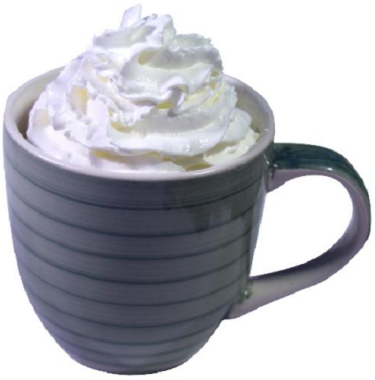



Appendix C

Table 8
Valence of word stimuli utilised in implicit association task

Word Stimulus	Valence
Negative	
attack	-0.80843
murder	-0.93498
victim	-0.76200
killer	-0.81504
stress	-0.76388
prison	-0.76739
sadist	-0.76131
cancer	-0.77896
crisis	-0.71597
incest	-0.72053
nausea	-0.79403
poison	-0.74654
torture	-0.91106
disease	-0.83697
tragedy	-0.76852
traffic	-0.75516
widower	-0.72723
assault	-0.78536
neglect	-0.75730
poverty	-0.75948
Positive	
rest	0.73484
grin	0.70472
joke	0.73104
award	0.76180
bonus	0.75112
wisdom	0.72606
winner	0.72358
achieve	0.72301
wisdom	0.72606
giggle	0.78811
delight	0.85881
laughter	0.72132
macaroni	0.72207
serenity	0.73657
sunshine	0.73640
faithful	0.70657
friendly	0.73624
enjoyment	0.83668
happiness	0.85671

sincerity	0.72114

Appendix D

Reflexivity Statement

Prior assumptions and experience

Within the context of the current study, the principal investigator (RH) had to consider how their background as a person living with type 1 diabetes (T1D) may have influenced their interactions with participants. An important question we needed to address when developing conclusions from the data was whether participants' knowledge of the lived experience of RH may have impacted the information they shared, such as the level of detail they included about issues such as accessing healthcare if the same experience was assumed to have been experienced by RH, or their willingness to discuss various topics, and how this may have shaped what was discussed during their interview.

Epistemological position of the study in the context of wider thesis

RH acknowledged the impact that their epistemological position could have potentially had prior to conducting the study interviews in that the basis of the current thesis was interested in looking at self-regulation in T1D, and as such took steps to ensure that the semi-structured interview schedule was devised in a way to reduce any prefabricated assertions during the interviews. This was also maintained when drawing conclusions from the data, which was analysed based solely on the information provided, and relations to the wider thesis were not drawn until this process was complete.

Potential for psychological harm

RH was acutely sensitive to the possibility that discussing the topics included in the research interview could potentially invoke negative feelings in the research participants. It was for this reason that RH made participants aware of their own lived experience with the condition

at the beginning of each interview, so that participants would gain a sense of solidarity and understanding from the researcher and as such was hoped to reduce any negative feelings arising.