# Executive function is associated with diabetes-specific disordered eating in young adults with type 1 diabetes

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A B S T R A C T

*Objectives:* Disordered eating behavior in young adults with type 1 diabetes is overrepresented and associated with significant negative health consequences. Thus, determining the key correlates of these behaviors is essential. The aim of the present study was to determine the association between executive function and disordered eating in young adults with type 1 diabetes, relative to a control group without diabetes.
*Methods:* 74 young adults with type 1 diabetes and 201 demographically similar control participants completed an online survey containing the Eating Disorders Examination Questionnaire (EDE-Q), Diabetes Eating Problems Survey- Revised (DEPS-R), Behavior Rating Inventory of Executive Function- Adult version, Depression Anxiety and Stress Scales, and 3 subscales of the Family Environment Scale (independence, control, and cohesion).
*Results:* Hierarchical multiple regressions showed that lower executive function was associated with significantly greater disordered eating (as measured by the DEPS-R) over and above psychological and family functioning in the type 1 diabetes group ($\Delta R^2 = 0.056$, $\beta = 0.366$, $p = .031$). The same relationship was not found when disordered eating was measured by the EDE-Q in either the diabetes group ($\Delta R^2 = 0.049$, $\beta = 0.342$, $p = .054$), or the control group ($\Delta R^2 = 0.010$, $\beta = 0.136$, $p = .100$).
*Conclusions:* Executive function may play a greater role in the development and/or maintenance of disordered eating in groups with type 1 diabetes relative to those without. This relationship may contribute to the over-representation of eating problems in this clinical group, and may represent a target for prevention or intervention.

## 1. Introduction

Previous research has found an over-representation of people with type 1 diabetes experiencing symptoms of disordered eating, including clinical eating disorders and engagement in bingeing and purging behaviors, restrictive dieting, driven exercise, and insulin restriction for weight control (e.g., [1–4]). While there is some variation in reported prevalence of these disturbances, approximately double the rates of both clinical and sub-clinical disordered eating have been reported in young females with type 1 diabetes relative to their peers without diabetes [5]. Intentional insulin restriction for weight control (as opposed to accidental under-dosing or dose restriction for other reasons) is reported in approximately 20–30% of this group [6,7] This is a unique method via which individuals with type 1 diabetes can induce weight loss via the process of glycosuria (i.e., loss of unabsorbed glucose in the urine) [8], and is the most prevalent and dangerous disordered eating behavior reported in young female populations with this condition (e.g., [9]). Disordered eating behaviors in this clinical group

often arise in adolescence, but persist well into adulthood and can be particularly difficult to treat [10–12]. Additionally, these behaviors are associated with relatively more severe adverse health outcomes in individuals with type 1 diabetes compared to those without [9,13]. Accordingly, research has aimed to elucidate the possible contributory factors involved in the relationship between type 1 diabetes and disordered eating. Broadly, these enquiries have explored family, mood, and diabetes-specific factors.

Family factors, such as the level of cohesion or conflict within the family unit, have been shown to influence eating behaviors in adolescent samples with type 1 diabetes [14–16]. It is proposed that the quality of the familial relationships and environment may have additional salience for individuals with diabetes, which may impact upon their food choices and eating behaviors [14]. Specifically, higher levels of diabetes-related conflict with immediate family members, and lower levels of cohesion (or closeness) in the family have been shown to be significantly associated with greater disordered eating in adolescents with type 1 diabetes [14,16]. Eating disturbances are still common in

young adults, however, and therefore the family dynamic may be less relevant for these individuals due to more autonomous management of diabetes care. Mood disturbances (including depression, anxiety, and stress) have also been identified as possible contributory factors to the development and maintenance of eating problems in type 1 diabetes, and may be more relevant to slightly older groups. Research has indicated that mood disturbances are more prevalent in this population (e.g., [17]), and relatively consistent associations between these and disordered eating have been shown [18,19]. However, one study found that mood factors were relatively *less* related to eating disorders in young adults with type 1 diabetes compared to a control population [20]. This may indicate a role of additional factors in precipitating or maintaining these behaviors.

Factors intrinsic to the experience, care, and management of type 1 diabetes have also been proposed to contribute to the development and maintenance of eating problems. For example, the burden of the regimented monitoring of diet, insulin, and exercise, combined with the weight gain that often results from the use of exogenous insulin, is associated with disordered eating in this group [10,15]. While these investigations have been a valuable addition to the literature, many of these diabetes-specific factors are difficult to modify, and the mechanisms through which these translate into disordered eating for some individuals but not others are unclear. It may be the case that other factors can offer further insights into the development and progression of eating problems in this unique population, and potentially offer strategies for prevention or intervention.

Higher order cognition, or executive function, may be a particularly important, as yet unexplored factor in the relationship between type 1 diabetes and disordered eating. Executive function refers to a set of cognitive processes involved in the execution of complex behaviors, reasoning, and decision making, and which are associated with frontal lobe function [21]. Previous research has indicated that executive function can be a problematic area for young adults with type 1 diabetes. For example, a recent meta-analysis showed lower executive function performance across domains of inhibition, working memory, and set-shifting in groups with type 1 diabetes relative to controls [22]. Additional studies have shown significant relationships between lower overall executive functioning (measured via self-report) and difficulties with diabetes treatment adherence [23,24]. The likely explanation for executive difficulties in this group is that stable glucose levels are imperative for optimum neural development and function; and that the efficiency of cognition, particularly executive function, is contingent on glucose availability (which is compromised in individuals with type 1 diabetes) [25,26]. It has been documented that glycemic disruption (both acute and chronic) within this group can bring about executive function changes (e.g., reduced capacity for self-control) that further facilitate difficulties with diabetes management, and potentially other psychological and behavioral difficulties [25].

In populations *without* type 1 diabetes, there is a plethora of research showing associations between disordered eating and difficulties with executive function, with cognitive pathways proposed as a mechanism for the development and maintenance of problematic eating thoughts and behaviors (e.g., [27,28]). Specifically, much of the research in this area has described relationships between reduced set-shifting ability (i.e., the ability to switch flexibly between tasks/goals) and disordered eating, perhaps reflecting rigid thinking styles, or an inability to reconcile the conflicting outcomes (i.e., risks versus rewards) involved in engaging in disordered eating behaviors [27]. However, additional research has shown links between executive function more generally and the regulation of eating behavior, as this domain of cognition is collectively responsible for the successful execution of complex behaviors in everyday life, such as those involved in eating-related contexts [29]. Given the established links between executive function and disordered eating, and type 1 diabetes and executive difficulties, it follows that the relationship between type 1 diabetes, executive function, and disordered eating should also be

explored. In this clinical population, it is possible that individuals particularly susceptible to executive problems will be the same individuals experiencing eating-related problems. For example, individuals with type 1 diabetes and poorer set-shifting ability may experience difficulties switching flexibly between possible "rewards" such as immediate hedonic pleasure of consuming or bingeing on unhealthy foods while avoiding consequent weight gain, and the risks of glycemic disruption, diabetic ketoacidosis, or long-term complications from behaviors such as insulin restriction. If established, this could lead to earlier identification of those at risk for disordered eating, and could present opportunities for supplementary preventative or intervention approaches focused on maximizing executive capacities and accommodating for these difficulties.

The primary aim of this study was to explore the relative contribution of executive function to eating-related disturbances in groups with versus without type 1 diabetes, controlling for other factors known to be involved in this relationship. Understanding the separate and overlapping relationships between these factors and their impact on eating behavior is essential for developing the most comprehensive understanding of how to prevent and treat these complex problems. It was hypothesized that executive function would be significantly related to disordered eating, and would be more strongly associated with disordered eating behaviors in those with type 1 diabetes relative to the control group.

## 2. Methods

### 2.1. Participants

Participants were recruited from the general community and the staff and student body of Queensland University of Technology via social media, online advertisements, online newsletters (state Diabetes organization publications), email notifications, and distribution of flyers. Inclusion criteria were age between 18 and 40 years, sufficient English language ability to complete the survey, and either no diabetes or a diagnosis of type 1 diabetes for at least 12 months.

### 2.2. Measures/procedure

The study protocol was approved by the University Human Research Ethics Committee. Participants provided informed consent and then completed an anonymous online survey including questions pertaining to eating behaviors and thoughts, executive functions, family environment, mood symptoms, and demographic and clinical information (e.g., HbA1c, complications).

Previous literature has noted that comparison between type 1 diabetes and control groups on eating behavior is difficult due to the need to use different measures of disordered eating [15]. The current study opted for a dual approach by using one measure to compare the two groups directly, and another measure to take into account the additional behaviors relevant to the diabetes group only. The Eating Disorders Examination Questionnaire (EDE-Q) was completed by all participants. This 28-item measure examines both disordered eating behaviors (e.g., "over the past 28 days, how many times have you made yourself sick (vomit) as a means of controlling your shape or weight?") and attitudes (e.g., "have you had a definite fear of losing control over eating?"). The EDE-Q has been validated on a large Australian community sample [30], implemented successfully in samples with type 1 diabetes (e.g., [3]), and displayed good psychometric properties (e.g., [31]). Higher scores are indicative of greater disordered eating behavior, and cut-off criteria can be applied to establish those at risk for clinical eating disorders [30].

The 16-item Diabetes Eating Problem Survey Revised (DEPS-R) was administered to the type 1 diabetes group as a diabetes-specific measure of disordered eating attitudes (e.g., "I would rather be thin than have good control of my diabetes") and behavior, including insulin