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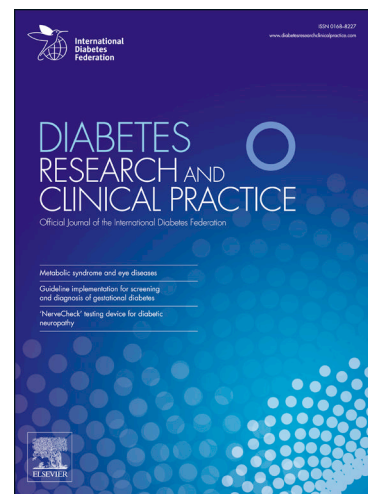
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**A Graduated Food Addiction Classifications Approach Significantly Differentiates  
Depression, Anxiety and Stress among People with Type 2 Diabetes**

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**Abstract**

**Aims:** To examine differences in depression, anxiety, and stress across people with type 2 diabetes mellitus (t2d) classified according to a four level processed food addiction (PFA) severity indicator dichotomy.

**Methods:** Four hundred and eight participants with a t2d diagnoses completed an online survey including the Yale Food Addiction Scale (YFAS) and the DASS-21. Based on YFAS symptom counts participants were classified as either: non-PFA; mild-PFA; moderate-PFA; or severe-PFA.

**Results:** Multivariate,  $\lambda = .422$ ,  $F(9, 978.51) = 46.286$ ,  $p < .001$ ,  $n_p^2 = .250$ , and univariate analyses of variance demonstrated that depression  $F(3, 408) = 159.891$ ,  $p < .001$ ,  $n_p^2 = .543$ , anxiety  $F(3, 408) = 127.419$ ,  $p < .001$ ,  $n_p^2 = .486$ , and stress scores  $F(3, 408) = 129.714$ ,  $p < .001$ ,  $n_p^2 = .491$ , significantly and meaningfully increased from one PFA classification level to the next. Furthermore, the proportion of participants with more severe classifications of depression  $\chi^2(12) = 297.820$ ,  $p < .001$ , anxiety  $\chi^2(12) = 271.805$ ,  $p < .001$ , and stress  $\chi^2(12) = 240.875$ ,  $p < .001$ , were significantly higher in the more severe PFA groupings.

**Conclusion:** For people with t2d, PFA is an important and meaningful associate of depression, anxiety, and stress, and that the adopted four level PFA severity indicator dichotomy is valid and useful.

**Key words:**

Type 2 diabetes mellitus, depression, anxiety, stress; processed food addiction; severity levels; processed food use disorder.

## **A Graduated Food Addiction Classifications Approach Significantly Differentiates Depression, Anxiety and Stress among People with Type 2 Diabetes**

### **1. Introduction**

Mood disorders, also known as affective disorders, are prevalent among people with type 2 diabetes mellitus (t2d) [1,2] and frequently co-exist with a cluster of other medical complications including obesity, hypertension, cancer, and heart disease [3]. Mood disorders have been strongly associated with Substance Use Disorders (SUDs), implying interactions between both maladies, which affect the course and diagnosis of both [4,5]. Together and separately, mood disorders and SUDs have been widely linked to a range of chronic conditions, including t2d [6]. Clinical evidence of SUDs and other mental illnesses have been found among people with t2d, implying multi-co-morbidity [6].

#### **1.1. Type 2 Diabetes and Psychological distress**

Diabetes prevalence world-wide continues to snowball at an alarming rate; it is recognised as the world's fastest growing chronic condition [7-9]. Depression has shown to be more prevalent in people diagnosed with t2d than in the general population [10,11] and is often analogous with anxiety [12,13]. Research demonstrates that moderate to severe depression and anxiety among people with t2d is more than double what would be expected in the general population [14,15]. Furthermore, developing t2d creates additional stress due to the long-term prognosis of the disease and the potential complications associated with this illness [16].

#### **1.2. Psychological distress and Substance Use Disorders**

Research has shown associations between mood disturbances and SUDs [17]. Sinha [18] reviewed empirical evidence demonstrating that chronic and acute stress were strongly associated with increased desires to abuse addictive substances. Moreover, Lai, et al. [19] performed a systematic review and meta-analysis of research published between 1990 and

2014 investigating prevalence rates of SUDs comorbid with mood and anxiety disorders; the strongest statistical relationships linked illicit drug use and major depression, illicit drug use and anxiety disorder, alcohol use and major depression, and alcohol use and any anxiety disorder. On an international scale, data from the Global Burden of Diseases, Injuries, and Risk Factors Study [20] summarised fatal, non-fatal, and total burden for 11 classes of mental diseases and SUDs, in regards to changes in burden since 1990. Internationally, mental diseases and SUDs contributed to over seven percent of the global burden of disease trumping other diseases such as tuberculosis, HIV/AIDS, and transportation accidents [3]. Clearly, there is strong evidence that psychological distress and SUDs are linked and associated with substantial economic burden and personal distress.

### **1.3. Type 2 Diabetes, Psychological Distress, and Substance Use Disorders**

Hitherto, empirical evidence has mainly focussed on dyads of diseases such as mental health and t2d, or mental health and SUDs [21]. Previously people with multiple health problems, multimorbidity, were somewhat overlooked in medical research [22]. However, research attention particularly linking primary healthcare and multimorbidity, has increased over the last two decades [21-25]. Despite such positive developments, research concerning the interplay of t2d, mental health, and SUDs has been limited. Research that has adopted this broader scope specific to t2d for example, Tann, et al. [26] has made important observations. Tann et al.'s [26] research with American Indians and Alaskan Natives suggests that the multimorbidity of alcohol abuse, depression, and diabetes have a much larger combined effect than they do individually (OR = 10.95; 95% CI = 2.98 – 40.32) when compared to a White population. Similarly, Wu et al. [6] demonstrated that among a t2d cohort, participants with a SUD (alcohol, tobacco, or drug use) were more likely to have a mood (OR = 2.229; 95% CI = 2.016 – 2.465) or anxiety diagnosis (OR = 1.857; 95% CI = 1.656 – 2.081).

Recent research has further progressed, linking food addiction (FA) (comparable to a DSM-5 SUD) with t2d psychological distress [27]. Empirical attention in the last decade continues to advance and support FA as a distinct construct with neurobiological, behavioural, and psychological criteria analogous to alcohol and drug abuse disorders [28,29]. Ifland et al. [30] suggests ‘refined foods’ are analogous to the manufacturing of addictive drugs using procedures including concentration and extraction, distillation, and crystallisation. Likewise, processed foods are refined and manufactured and because of this refining process are no longer natural. Moreover, ‘*food addiction*’ has had many and varied labels including: chocolate addiction [31], processed foods addiction [27,30,32-34], eating addiction [35], problem with highly processed foods [36], physically and psychologically dependent on high fat, high sugar (HFHS) foods [37], and ultra-processed foods addiction [38]. From this point forward we have adopted the term ‘processed food addiction’ (PFA) to facilitate greater research direction and consistency.

#### **1.4. Processed Food Addiction**

Processed food addiction has previously been strongly associated with body mass index (BMI) in people with t2d [27,39,40], a key risk factor for the development and complications of t2d. Raymond and Lovell [2] demonstrated multimorbidity among those participants with t2d meeting a FA criteria [41] with higher depression, anxiety, and stress scores compared to those that did not. Also, worthy of note was that FA symptomology accounted for a greater proportion of depression, anxiety, and stress scores (35%, 34%, 34% respectively) than participants’ BMI (< 1%).

Recently, Raymond et al. [27] focussing on BMI in a sample of people with t2d, introduced and tested severity specifiers for PFA in line with the DSM-5 nomenclature for other (or Unknown) SUDs, such as alcohol, opioids and stimulants [42]. Conclusions included that a 4 level classification of PFA based on YFAS symptoms count was valid: none

and one YFAS symptom = non-PFA; two symptoms = mild-PFA; three or four symptoms = moderate-PFA; and five, six, or seven symptoms = severe-PFA. Results also demonstrated the four severity indicators aligned with WHO BMI obesity classifications: the more severe the PFA classification, the more obese the WHO BMI classification.

The impetus for this current research was the consideration that previous binary approaches to PFA (either one has PFA or one does not), and the lack of a graduated measure of PFA symptomatology analogous to Other Substance Use Disorders [42] limited theoretical understanding and practical treatment of PFA. Based on the demonstrated relevance of psychological distress and PFA for people with t2d, we investigated depression, anxiety, and stress across people with t2d of different PFA classifications. Specifically, we hypothesised that there would be significant differences between PFA severity groups' (non-PFA, mild-PFA, moderate-PFA and severe-PFA) psychological distress (depression, anxiety and stress) scores. Not only would findings of this research have important implications for the further development of theoretical understandings of PFA and psychological distress associated in people with t2d, but also in terms of informing addiction orientated practical interventions to ameliorate psychological distress in this specific population.

## **2. Method**

### **2.1. Participants and procedure**

As part of a larger study, following institutional ethical approval, participants over 18 years of age with a current medical practitioner diagnosis of t2d were recruited on a volunteer basis to take part in an online survey set on the SurveyMonkey platform. The survey involved participants providing basic demographic information including t2d diagnosis, age, gender, domicile, height, and weight) along with self-report measures of PFA (YFAS) [41], depression, anxiety, and stress (DASS-21) [43]. Participants' informed consent was indicated

by completion of the survey. Recruitment was achieved through advertisements and flyers at Australian medical centres, social media (including Facebook and Twitter), and online diabetes media sites (Diabetes Australian and Diabetes UK), as well as letters sent out to medical practitioners. Data regarding participants' demographics and BMI have already been published in Raymond et al. [27].

Of the 484 participants that started the survey, 17 withdrew immediately after informed consent, 10 withdrew during the survey, 45 did not confirm they had a current t2d diagnosis, and four did not provide height and weight data. Of the final sample (N = 408), 48.2% from were from Australia with the remaining 52.8% participants from: USA (25.7%), UK (22.5%), New Zealand (1.7%), and other (1.7%: including Germany, Ireland, Malaysia, Norway, and Spain); 0.5% did not report their domicile. One participant (0.2%) had an underweight BMI ( $16.1 \text{ kg/m}^2$ ), 9.1% of the participants were in the normal BMI category ( $\geq 18\text{-}24.9 \text{ kg/m}^2$ ), 13.7% were categorised as overweight ( $\geq 25\text{-}29.9 \text{ kg/m}^2$ ), and 77.0% were categorised as obese ( $\geq 30 \text{ kg/m}^2$ ). Participants' age, height, weight and BMI are shown in table 1.

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Insert table 1 approximately here

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## **2.2. Measures**

### **2.2.1. Depression, Anxiety and Stress Scale (DASS-21), short version.**

The DASS-21 [43] is a 21-item (short-form version) self-report measure yielding three scales of seven items each to measure depression, anxiety or stress (psychological distress). Utilising a 4-point scale: 0 = "Did not apply to me at all"; 1 = "Applied to me to some degree, or some of the time"; 2 = "Applied to me to a considerable degree or a good



part of the time”; or 3 = “Applied to me very much, or most of the time” participants determined how much each statement applied to them over the past seven days. The range of possible scores for each of the three subscales is 0 – 21, where a higher score represents a higher level of depression, anxiety or stress. Totalling up the scores from each subscale has shown to be reflective of general psychological distress [44]. The DASS-21 has demonstrated to be an adequate measure of depression, anxiety, stress and psychological distress with reliable Cronbach’s alpha internal consistencies of 0.88, .082, 0.90, 0.93 respectively; compared to other measures of depression and anxiety the DASS-21 has exhibited satisfactory convergent and discriminate validity [44].

### **2.2.2. Yale Food Addiction Scale (YFAS).**

Process Food Addiction severity was determined by employing the YFAS [41], a 25-item self-report scale designed to measure FA over the past 12 months to clearly discern between persons with and without addictive eating behaviours. The YFAS is based on the seven substance abuse criteria in the DSM-IV [45]. The YFAS has shown good internal consistency ( $\alpha = 0.86$ ) [41] and psychometric properties have also been reflected in a German version [46], a French version [28], and a version for children (YFAS-C) [47]. Participants’ severity indicators of PFA were based on YFAS symptoms count: non-PFA = 0 or 1 symptom; mild-PFA = 2 symptoms; moderate-PFA = 3 or 4 symptoms; and severe-PFA = 5 or more symptoms [27].

### **2.3. Data analysis**

Statistical analyses were conducted using SPSS (version 24; SPSS Inc., Chicago, IL, USA).

## **3. Results**

Data were screened to ensure compliance with appropriate assumptions. Scales' and subscales' internal consistency were analyzed via Cronbach alpha calculations; all were found to be satisfactory. Dependent variables' descriptive statistics, intercorrelations, and Cronbach alphas are reported in Table 2.

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### 3.1. Psychological Distress Differences

One-way multivariate analysis of variance with PFA classification as the independent variable and DASS-21 depression, anxiety, and stress as the multiple dependent variables, returned a significant omnibus PFA classification main effect with large effect size,  $\lambda = .422$ ,  $F(9, 978.51) = 46.286$ ,  $p < .001$ ,  $n_p^2 = .250$ . Subsequent univariate tests of the same design demonstrated significant PFA classification main effects with large effects for each of the dependant variables: depression  $F(3, 408) = 159.891$ ,  $p < .001$ ,  $n_p^2 = .543$ ; anxiety  $F(3, 408) = 127.419$ ,  $p < .001$ ,  $n_p^2 = .486$ ; and stress  $F(3, 408) = 129.714$ ,  $p < .001$ ,  $n_p^2 = .491$ . Post hoc Fisher's least significant difference (LSD) tests showed that each of DASS-21 measure scores significantly increased from one PFA classification participant grouping to the next (see Figure 1).

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Insert figure 1 approximately here

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### 3.2. Depression, anxiety, and stress severity indicators

As shown in Table 3, approximately three quarters of participants with t2d categorised as non-PFA had normal levels of depression, anxiety, and stress. For both

depression and anxiety, the percentage of participants with more severe psychological distress classifications systematically increased with increasing PFA classifications; approximately 60% of participants with severe PFA had extremely severe depression, and 70% had extremely severe anxiety. Stress followed a similar pattern, with just less than half the participants with severe PFA having moderate levels of stress and 34.4% with severe levels of stress.

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Insert table 3 approximately here

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#### **4. Discussion**

Our aim in this study was to test the hypothesis that for people with t2d, PFA severity classifications (non-PFA, mild-PFA, moderate-PFA, and severe-PFA) would significantly differ on depression, anxiety, and stress, with higher PFA severity indicators having higher scores. Findings supported our hypothesis demonstrating that participants with more severe PFA had significantly and meaningfully higher levels of depression, anxiety, and stress. Furthermore, the majority of those participants who met the severe-PFA classification (5 or more symptoms) had extremely severe levels of depression and anxiety (59% and 70% respectively). A similar pattern of results was observed for PFA severity and stress, although to a more modest degree. Participants in this sample without PFA were more likely to have normal stress levels and people with severe PFA were more likely to have moderate stress levels.

Results of this study corroborate previous correlational findings for people with t2d, demonstrating a relationship between PFA and depression, anxiety, and stress [2].

Importantly, this current research has extended the current body of knowledge by exploring how psychological distress varies across previously published PFA severity indicator classifications, with important implications for treatment and prevention methodologies.

Additionally, in a previous study it was acknowledged that the mild-PFA group (2 symptom count) only represented 7% of the sample [27] and the meaningfulness of this classification was questioned. In this current study, the presence of statistically significant and meaningful differences in depression, anxiety, and stress between the mild-PFA and non-PFA, as well as moderate-PFA, do provide additional evidence that this PFA classification does appear valid and useful; further confirming the proposed four level dichotomy

#### **4.1. Limitations and future research**

This study has limitations. As a cross-sectional study, we cannot make any definitive conclusions regarding a causal relationship between psychological distress and PFA. Using self-report assessments may have questionable reliability and validity, and be limited in determining a clinical diagnosis. Self-report measures may increase the likelihood of participants providing inaccurate information, especially when asking sensitive details such as a person's body weight, due to past stigmatisation with obesity and body image [48]. However, while acknowledging these potential limitations, previous research using similar methodologies have produced valid and meaningful results. Despite all participants reporting a current health professionals' diagnosis of t2d, we did not collect objective indices of t2d status such as HbA1C. These data were not collected as anecdotal evidence suggests that the majority of Australian's with t2d do not know their HbA1C scores and that only 7% of a US sample of people with t2d were fully adherent to the ADA-recommended A1C testing frequency in 1 year [49]. Based on the decision to reduce questionnaire fatigue, we did not attempt to collect HbA1C data.

It is unknown whether these results are unique for people with t2d; no data or previous research were found through our extensive online searches of literature regarding associations between PFA and depression, anxiety, and stress in samples without t2d. As such, future research should consider how PFA and psychological distress relationships compare across different sample types.

In terms of research implications about furthering the knowledge base in this topic area, developments in current understanding as well as application have been compromised by the inconsistent use of terms to describe addiction in the context of uncontrolled food consumption and addictive behaviours related to the ingestion of high calorie foods. We encourage future discussions in the 'PFA' domain to reach better agreement on this universal term for the construct of food and addiction. Based on our research and previous research in this area [27-28,34,39], and to better facilitate a coherent approach to the study and conceptualisation of this phenomenon, with particular importance to t2d, we propose that PFA be the term of choice.

Our research demonstrates the relevance of much needed further work to reach a universal consensus on the diagnostic criteria, maintaining factors of PFA, and treatment models. This in turn provides rationale for future studies and practices in addressing questions relevant to clinicians treating patients with t2d including; whether taking advantage of a PFA treatment model with severity indicators, in unison with current t2d treatments, may bring about positive outcomes among those people with t2d.

#### **4.2. Practical implications**

In terms of implications for practice, based on our findings we are proposing that for a proportion of people with t2d, interventions that merely focus on addressing the symptoms of psychological distress, as well as obesity, without addressing the underlying disease of addiction, are unlikely to resolve the primary pathology. We argue in the early stages of the

diagnosis and treatment planning, screening of PFA severity should be conducted. Based on results of this screening, those individuals seen to have high levels of PFA could then be treated, alongside current t2d treatment modalities, with addiction specific based intervention methods. This would appear as a likely efficacious *modus operandi* for people who as yet have been unsuccessful in managing their psychological distress and obesity through traditional approaches. This novel approach to symptomologies in this population represents a fruitful avenue for future research, both in clinical and in practice among people with t2d.

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The authors declare that there is no conflict of interest.

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Table 1

*Sample Descriptives (N = 408; 32.6% Males)*

Measurement	Mean	SD	Range
Age (years)	41	8.9	18-64
Weight (kg)	108.3	23.9	46-200
Height (cm)	172.5	9.8	154-210
BMI (kg/m <sup>2</sup> )	36.5	7.9	16.1-60.8

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Table 2

*Dependent Variables' Descriptive Statistics and Intercorrelations*

Measure	Cronbach alpha	<i>M</i>	<i>SD</i>	DASS-21 Depression	DASS-21 Anxiety	DASS-21 Stress
YFAS	.941	4.72	2.19	.753*	.754*	.719*
DASS-21 D	.939	11.28	5.66	-	.821*	.851*
DASS-21 A	.890	8.82	5.12		-	.847*
DASS-21 S	.908	10.79	4.75			-

Note. \*  $p < .001$

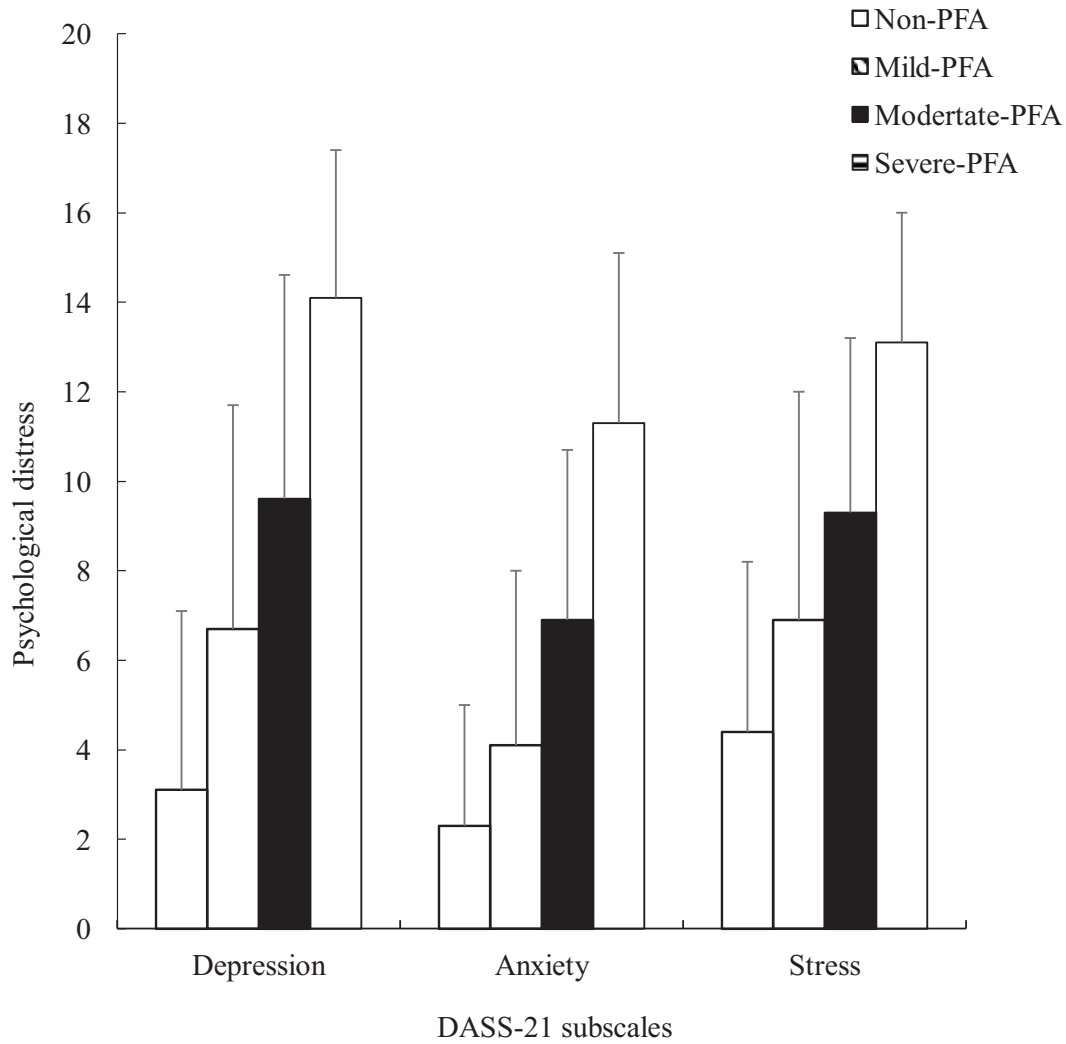
Table 3

*Percentage of Sample of People with Type 2 Diabetes Classified by PFA Severity.*

*Presenting with Normal, Mild, Moderate, Severe or Extremely Severe Depression, Anxiety, and Stress DASS-21 Severities.*

	DASS-21 Severity Category				
	Normal	Mild	Moderate	Severe	Extremely severe
<b>Depression*</b>					
Non-PFA	77.8	4.8	11.1	1.6	4.8
Mild-PFA	37.9	27.6	10.3	10.3	13.8
Moderate-PFA	12.5	11.5	26.9	25.0	19.2
Severe-PFA	1.2	.8	10.4	29.0	58.7
<b>Anxiety*</b>					
Non-PFA	77.8	6.3	12.7	0	3.2
Mild-PFA	51.7	20.7	17.2	3.4	6.9
Moderate-PFA	18.5	11.1	29.6	14.8	25.9
Severe-PFA	2.7	2.7	8.8	16.2	69.6
<b>Stress*</b>					
Non-PFA	69.8	20.6	6.3	1.6	1.6
Mild-PFA	51.7	24.1	3.4	13.8	6.9
Moderate-PFA	18.5	29.6	40.7	7.4	3.7
Severe-PFA	1.1	9.5	47.3	34.4	7.6

*Note.* \* significant Chi-squared test for independence: DASS-21 depression  $\chi^2(12) = 297.820$ ,  $p < .001$ ; DASS-21 anxiety  $\chi^2(12) = 271.805$ ,  $p < .001$ ; DASS-21 stress  $\chi^2(12) = 240.875$ ,  $p < .001$ .



*Figure 1: Mean and standard deviation depression, anxiety, and stress DASS-21 scores of PFA severity participant classification groupings.*

- In our sample of people with a current diagnosis of type 2 diabetes mellitus (t2d), four distinct processed food addiction (PFA) symptom severity groups were evident: non-PFA = 0 or 1 symptom; mild-PFA = 2 symptoms; moderate-PFA = 3 or 4 symptoms; and severe-PFA = 5 or more symptoms.
- Participants classified as having more severe (PFA), had significantly higher levels of psychological distress: depression, anxiety, and stress.
- The percentage of participants classified as having more severe psychological distress systematically increased with increasing PFA classifications.
- This finding has implications for the treatment and prevention of depression, anxiety, and stress in people with t2d.
- We propose addiction based models of treatment would appear as a likely efficacious approach for people with t2d who have as yet been unsuccessful in managing their psychological distress through traditional approaches.