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'Do no harm' - the impact of an intervention for addictive eating on disordered eating behaviours in Australian adults: secondary analysis of the TRACE randomised controlled trial

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Abstract

Background Designing interventions to change addictive eating behaviours is a complex process and understanding the treatment effect on co-occurring disordered eating behaviours is of importance. This study aimed to explore treatment effects of the TRACE (Targeted Research for Addictive and Compulsive Eating) intervention for addictive eating on eating disorder psychopathology, binge eating, reward driven eating and grazing behaviours.

Methods This study involved secondary analysis of data from a randomised control trial among 175 participants (18–85 yrs) endorsing ≥ 3 Yale Food Addiction Scale (YFAS) symptoms who were randomly allocated to (1) active intervention, (2) passive intervention, or (3) control group. Change in YFAS, EDE-Q 6.0, Binge Eating Scale, RED-X5 and Short Inventory of Grazing scores were assessed at 3-months (immediate post-intervention) and 6-months (3-months post-intervention) follow-up.

Results Using Linear Mixed Models, from baseline to 3-months there was a significant reduction in eating disorder global scores in the active intervention [mean decrease −0.6 (95% CI: -0.8, -0.4)], but not in the passive intervention [-0.2 (95% CI: -0.5, 0.1)] or control groups [-0.1 (95% CI: -0.3, 0.1)]. In the active and passive intervention groups there were significant reductions in reward driven eating [-3.8 (95% CI: -4.9, -2.7; -2.5 (95% CI: -3.9, -1.1), respectively], compulsive grazing (-1.8 (95% CI: -2.4, -1.3); -1.1 (95% CI: -1.7, -0.5), respectively] and non-compulsive grazing scores (-1.4 (95% CI: -1.9, -1.0); -1.1 (95% CI: -1.7, -0.4), respectively], but not in the control group. The reduction in binge eating scores over time was similar for all groups. The reduction in addictive eating symptoms from baseline to 3-months was positively associated with the reduction in eating disorder global scores, binge eating, reward driven eating and grazing behaviours (r_s ranged from 0.23 to 0.69).

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Conclusion The dietitian-led TRACE intervention which adopted a weight-neutral, harm reduction approach for the management of addictive eating in adults demonstrated positive effects on some co-occurring disordered eating behaviours. Importantly the intervention did not cause any adverse changes in the eating disorder pathologies measured.

Trial registration Australia New Zealand Clinical Trial Registry ACTRN12621001079831.

Plain English summary

Addictive eating is increasingly recognised in the community however designing treatments to improve these behaviours is complex due to the co-occurring disordered eating behaviours. This study aimed to explore treatment effects of the TRACE (Targeted Research for Addictive and Compulsive Eating) intervention on eating disorder outcomes in adults. Following a 3-month telehealth intervention delivered by dietitians there were improvements in eating disorder scores, grazing and reward driven eating for the telehealth intervention. These results are important and highlight that treatments for food addiction delivered by trained dietitians can be beneficial in improving addictive eating and disordered eating outcomes.

Keywords Addictive eating, Food addiction, Disordered eating, Eating disorders, Mental health, Harm reduction, Randomised controlled trial

Introduction

Disordered eating encompasses a range of eating-related behaviours that may or may not directly align with diagnostic criteria for an eating disorder [1]. This includes, but is not limited to, compulsive overeating, binge eating, grazing, preoccupation with food, loss of control around food, and eating marked by psychological distress [1]. These maladaptive behaviours, often associated with higher weight status [2], can negatively impact physical health, mental health, and overall quality of life [3, 4]. Addictive eating or 'food addiction' is a pattern of disordered eating that mirrors behaviours typically associated with substance-use disorders, including limited control over the intake of highly palatable, high-caloric foods, "withdrawal-like" physiological effects if food intake is stopped or reduced, tolerance and cravings [5]. The similarities with clinical eating disorders have also been acknowledged, most notably with Binge Eating Disorder and the non-purging form of Bulimia Nervosa [6, 7]. Both of these eating disorders are characterised by recurrent episodes of excessive and uncontrolled food consumption, accompanied by psychological distress [6, 8].

Although not yet recognised as a distinct disorder in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) [9], or as a clinical diagnosis by the International Classification of Diseases (ICD-11) [10], addictive eating is most frequently measured using the Yale Food Addiction Scale (YFAS) [5, 11] based on DSM criteria for substance use disorders. Significant associations have been reported between higher YFAS scores and increased eating disorder psychopathology [12–14], as well as a range of disordered overeating behaviours such as binge eating [8, 15], reward driven eating and grazing [16, 17]. Further research demonstrates these varying patterns of overeating; often characterised by a preoccupation with food, lack of satiation, and loss of control [18]; contribute to addictive eating severity and that compulsive tendencies towards food in any form may be a marker of addictive eating therefore clinical intervention is warranted [19].

While many disordered eating behaviours may not reach levels of frequency or severity to fulfil clinically diagnostic eating disorders criteria, they typically cluster with other health conditions (e.g., Type 2 diabetes mellitus [20, 21], hyperlipidaemia [22] and hypertension [23, 24]), and are associated with adverse health outcomes or risk factors. These include overweight and obesity [25, 26], weight gain over time [27], anxiety and depression [28]. Higher weight status in particular may precede the onset of eating disorders, representing a risk factor for the onset or partly the consequence of disordered eating behaviours [29, 30]. With the elevated risk that disordered eating behaviours pose to both physical and mental health, and mounting evidence indicating a growing prevalence of eating disorders in individuals with higher weight status [30, 31], there is growing research into treatment options for disordered eating with some showing promise. This includes transdiagnostic therapy [32, 33] which integrates psychotherapeutic interventions for eating disorders (cognitive behaviour therapy – enhanced, or CBT-E) with multi-disciplinary nutrition and physical activity education, and behavioral weight loss therapies [34]. However, given there are only a small number of published intervention studies (see reviews [35, 36] and [37–41]), and the time taken for translation of research into healthcare practice, accessing treatment for addictive eating currently relies mostly on self-help options [42]. Furthermore, there is ongoing debate regarding the efficacy of an abstinence-based approach, an inherent component of online addictive eating recovery programs (e.g., Overeaters Anonymous [43], Food

Addicts Anonymous [44]), versus a moderation approach for the management of addictive eating [45].

Traditionally, abstinence-based models of addiction recovery have been applied in Substance Use Disorder treatment [46]. However, there is evidence that total abstinence is not a requisite for achieving addiction recovery for all individuals [46], and may not be the best approach for addictive eating behaviours. Harm reduction is an alternative approach that prioritises reducing the negative consequences of the health behaviour over complete abstinence [47]. This model recognises that abstinence may not work for everyone and that the journey towards sustained behaviour change may involve various stages of readiness [48]. The integration of harm reduction principles (i.e., humanism, pragmatism, autonomy, incrementalism, individualism, and accountability without termination [47]) into treatment approaches across health settings may be beneficial in reducing stigma associated with health risk behaviors, a key barrier to accessing treatment [47, 49].

Given that consumption of food is an essential part of everyday life, and many factors (e.g., neurobiological [50], social [51], environmental [52]) influence an individual's eating behaviours, the goal of abstinence from foods that are habitually overeaten or craved may seem intuitive, but can be difficult to achieve and maintain long term. It has been suggested that an abstinence-based approach may be harmful and increase the risk of disordered eating behaviours (e.g., restrictive eating practices) [32, 53]. Several controlled trials [54] have shown that food-based exposure interventions, including exposure response prevention (ERP) therapies [55], are generally well-accepted and tolerated in binge eating disorder and bulimia nervosa leading to improved outcomes. For the management of addictive eating, adopting a non-abstinence approach with exposure to all foods may provide a more realistic option to restore healthy eating patterns with continued adherence over the longer-term. A non-abstinence approach consistent with CBT-E based intervention encourages consumption of all foods in moderation, including self-identified problematic foods, in conjunction with coping skills training to reduce vulnerability to dysregulated eating behaviours [36]. This would align with current evidence-based recommendations for eating disorders [56].

The TRACE (Targeted Research on Addictive and Compulsive Eating) program was developed using co-design (health professionals and individuals with lived experience of addictive eating), based on an efficacious brief behavioural intervention for alcohol use [57, 58]. The program offers a personalised approach to improve addictive eating and mental health. The dietitian-led program, delivered via telehealth, incorporates personalised feedback and harm reduction strategies to promote positive eating behaviour change including goal setting to achieve healthy, balanced, and regular eating patterns; coping strategies to manage overeating; self-monitoring of progress, and problem-solving to create awareness around overeating. It is common for individuals seeking help with addictive eating behaviours to have undertaken previous programs with a central focus of weight loss [59]. Although weight management interventions have been found to have positive effects on disordered eating behaviours [60], participants in the TRACE program are encouraged to establish realistic eating goals that are not focused on weight loss as an outcome and which do not involve complete dietary restriction or abstinence from any foods.

Findings from the TRACE randomised controlled trial (RCT) demonstrated significant improvements in the primary outcome for symptoms and severity of addictive eating, as well as psychological improvements in mental health symptomology (anxiety, depression and stress) [61], and improvements in diet, sleep and physical activity [62]. Significant improvements were also found for participants who completed the program using a self-guided approach (self-paced completion of the program workbook [63] without telehealth session component), while an economic evaluation found the program to be inexpensive for both the telehealth and self-guided delivery, and both formats led to small Quality Adjusted Life Year gains [64].

Designing interventions to change addictive eating behaviours is a complex process, which includes defining the types of change that are needed and implementing appropriate practices for multifaceted behaviour change. Individuals attempting to manage symptoms of addictive eating may be especially prone to or worsening of eating-related pathologies [65]. For example, internalised weight bias and body shame [65, 66]. More recently dietary restraint as a feature of disordered eating has been discussed as an important contextual factor related to addictive eating [67]. With increasing evidence demonstrating the overlap, there is a need to consider these behaviours collectively to better understand the relationships as well as the impact on weight status to ensure the health needs of individuals are met as treatment approaches continue to evolve. Of importance is understanding the intervention effect on the problematic eating behaviours that commonly coincide with addictive eating. The hypothesis being that the intervention would have no adverse effect on these behaviours.

Therefore, the aim of this secondary analysis was to (1) explore treatment effects of the TRACE intervention on disordered eating behaviours, specifically eating disorder psychopathology, binge eating, reward driven eating and grazing, at 3-months (immediate post-intervention) and 6-months (3-months post intervention) follow-up; and

(2) examine the association between change in addictive eating and disordered eating behaviour outcome scores from baseline (pre-intervention) to 3-months (immediate post-intervention).

Methods

Study design

A full description of the study design has been previously published [61, 68]. In brief, the TRACE study was a 3-arm parallel, non-blinded randomised controlled trial. Individuals aged 18–85 years, endorsing 3 or more YFAS symptoms, with a body mass index (BMI) ≥ 18.5 kg/m^2 were included. Exclusion criteria included pregnancy/lactating, existing health condition/s that necessitated taking medications which affect dietary intake or weight status, severe mental illness, and purging behaviours. Participants were stratified by sex and mental health status (presence or absence, based on either depression scale (Patient Health Questionnaire– 8) scores ≥ 15 or below 15, or anxiety scale (Generalized Anxiety Disorder – 7) scores ≥ 11 or below 11) and randomised to either the (1) active intervention, (2) passive intervention, or (3) control group (for full details of sample size calculation, randomisation procedures and blinding see [68]). Participants completed outcome measures (via online survey) at baseline, 3-months (immediate post intervention) and 6-months (3-months post intervention).

In a stepped care model, the TRACE active intervention involved five telehealth sessions over 3-months with an Accredited Practising Dietitian with > 10 years' experience in private practice and trained in eating disorder management. Sessions were supported by a program workbook and study specific website. The passive intervention involved a self-guided approach with participants given access to the program workbook and website, but no telehealth sessions. Participants in both intervention arms received personalised feedback from their baseline surveys on dominant personality trait/s that may be associated with increased risk of addictive behaviours (e.g., anxiety proneness, impulsivity proneness); symptoms of addictive eating; dietary, caffeine and alcohol intake; sleep hygiene and physical activity levels. Participants in the control group were provided with dietary feedback at baseline only and asked to continue their usual dietary pattern for 6-months, with access to the passive intervention offered on study completion (for full details of the protocol see [68]).

Ethical approval For the TRACE RCT (Australia New Zealand Clinical Trial Registry ACTRN12621001079831) clearance was obtained from The University of Newcastle Human Research Ethics Committee (H-2021-0100) and online informed consent obtained from all participants prior to trial commencement. The findings of this analysis are reported in accordance with Consolidated Standards of Reporting Trials (CONSORT) guidelines [69].

Outcome measures

Addictive eating behaviours

The primary outcome was change in addictive eating behaviours measured using the Yale Food Addiction Scale 2.0 (YFAS 2.0) [11]. The YFAS 2.0 is a validated self-report 35-item tool that assesses addictive eating behaviours and provides a symptom score ranging from zero to 11, as well as impairment/distress from eating. A symptom is considered met when one or more of the relevant questions for each symptom meets a predefined threshold. Severity of addictive eating is classified as mild (2–3 symptoms), moderate (4–5 symptoms) or severe (6 + symptoms).

Other eating behaviours

Secondary outcomes included the change in eating disorder behaviours, binge eating, reward-driven eating and grazing behaviours.

Eating disorder behaviours were measured using the Eating Disorder Examination Questionnaire 6.0 (EDE-Q 6.0) [70]. The EDE-Q 6.0 is a validated self-report 28-item questionnaire that assesses the occurrence and frequencies of key eating disorder behaviours with cognitive subscales related to eating disorders (restraint, eating concern, shape concern, and weight concern). The EDE-Q 6.0 asks participants to rate on a 7-point scale the frequency or severity of core symptoms and related psychopathological behaviors and beliefs over the past 28 days. Subscale and global scores, ranging from 0 to 6, reflect severity of eating disorder psychopathology. An EDE-Q score of three or more indicates a level of illness severity within clinical range [71].

Binge eating was measured using the Binge Eating Scale (BES) [72]. The BES is a validated self-report 16-item questionnaire to assess the presence of certain binge eating behaviours, over the past 28 days, which may be indicative of an eating disorder. Each item contains 3–4 statements about behaviours, thoughts, and emotional states. Total scores range from 0 to 46, and higher scores indicate more severe binge eating behaviours. Severity is defined using the following cut-offs: ≤ 17 = 'no binge eating', 18–26 = 'mild to moderate binge eating', > 27 = 'severe binge eating'. The BES, as originally proposed by Gormally et al. [72], has been shown to have a 2-factor structure [73], which relates to (1) behavioural manifestations of binge eating (e.g., eating large amounts of food; items 1, 3, 6, 7, 12, 14, 15; total scores ranges from 0 to 21), and (2) emotions/cognitions related to binge eating (e.g., e.g., guilt, fear of being unable to stop eating; items 2, 4, 5, 8, 9, 10, 11, 13, 16; total scores ranges from 0 to

25). For the current study, in addition to the total score, the two-factor scores were determined.

Reward driven eating was measured using the Reward-Based Eating Drive Scale (REDX-5) [18]. The REDX-5 is a validated self-report 5-item questionnaire, in 5-point Likert scale format from 1 (strongly disagree) to 5 (strongly agree), that assesses reward-driven eating (loss of control over eating, lack of satiety, and preoccupation with food). Total scores range from 0 to 20, and higher scores reflect higher reward-based eating drive.

Grazing frequency was measured using the Short Inventory of Grazing (SIG) [74]. The SIG is a validated self-report 2-item measure to assess (1) the presence and frequency of grazing in general [i.e., non-compulsive grazing, repeatedly (more than twice in the same time period during the day) picking or nibbling small amounts of food outside of planned meals and snacks], and (2) the presence and frequency of grazing accompanied by a sense of loss of control (i.e., compulsive grazing, occasions of grazing characterised by a an inability to resist eating or being driven/compelled to eat). Frequency is rated on a 7-point scale (0 to 6) ranging from "none at all" to "eight or more times per week". Higher scores indicate a higher grazing frequency with severity defined as 'None' = none or less than weekly, 'Mild' = 1–3 times a week, 'Moderate' = 4–7 times a week, 'Severe' = 8 or more times a week.

Anthropometric measures

BMI was calculated, from self-reported weight and height at each timepoint, using standardised techniques and categorised according to the World Health Organization adult cut-off points [75].

Statistical analysis

The analysis was conducted as an intention-to-treat (ITT) analysis including all randomised participants. All available data was used with no imputation of missing values at 3 and 6-months. A complete case analysis was also conducted where only participants with complete primary and secondary outcome data for all timepoints were included. *Descriptive statistics*: the results were assessed for normality and initially analysed using descriptive statistics. Between group differences at baseline were assessed using chi squared, Fisher's exact test or analysis of variance (ANOVA), as appropriate. Due to the small number reporting 'Other/non-binary' ($n=1$), between group differences for 'sex' were assessed for participants reporting 'male' or 'female' only. *Modelling*: For change in eating behaviour scores (addictive eating, eating disorder psychopathology, binge eating, reward-driven eating and non-compulsive/compulsive grazing) and BMI, Linear Mixed Models were used with main effects for group (active intervention, passive intervention, control) and time (treated as categorical at levels baseline, 3 and 6 months), and the group-by-time interaction. An unstructured residual covariance structure was used to allow for correlation between the repeated measurements for a subject. As previous research has demonstrated positive associations between addictive eating, binge eating and weight status [8], BMI was examined for possible moderating effects on the effect size of eating behaviour outcomes. *Associations*: a change score that reflects the difference between pre- and immediate post-intervention (i.e. difference between baseline and 3-month follow-up) was calculated for the number of addictive eating symptoms and each disordered eating behaviour outcome (eating disorder psychopathology, binge eating, reward-driven eating and non-compulsive/compulsive grazing). Spearman's rank correlations were then performed between change scores to determine whether the change in the number of addictive eating symptoms was associated with changes in disordered eating behaviour outcomes. As this was an exploratory analysis of preplanned secondary outcomes, adjustment for multiple comparisons was not conducted [76]. A p-value <0.05 was considered statistically significant. All statistical analyses were performed using IBM SPSS Statistics (Version 26).

Results

One hundred and seventy-five participants were randomised, with $n=58$ allocated to active intervention, $n=60$ to passive intervention and $n=57$ to the control group. Of the total sample, secondary eating behaviour outcome measures (i.e., EDEQ-6.0, BES, REDX-5 and SIG) were completed by $n=97$ participants at 3-months ($n=38$, active intervention; $n=22$, passive intervention; $n=37$, control group) and $n=79$ at 6-months ($n=28$, active intervention; $n=18$, passive intervention; $n=33$, control group). The remaining participants either formally withdrew from the study ($n=5$), completed a shortened version of the follow-up surveys [68] which did not include secondary outcome eating behaviour measures ($n=2$, 3-month; and $n=3$, 6-month surveys), or were lost to follow-up ($n=88$, did not complete 3 and/or 6-month follow-up surveys). From baseline to 3-months, attrition rates were higher in the passive intervention group compared to the active intervention and control groups. From 3- to 6-months attrition rates were similar across groups. At baseline, there was no significant difference between groups for age, sex or BMI (all $p>0.05$). The mean age of the total sample was 47.9 ± 13.2 years (range 21–75), the mean BMI was 35.6 ± 7.5 kg/m^2 with 96% of participants classified as having a higher weight status ($n=33$, BMI $\geq$ 25–29.9 kg/m^2; and $n=134$, BMI ≥ 30 kg/m^2), and 83% were female ($n=146$, female; $n=28$, male; $n=1$, 'Other/non-binary'). The majority of participants (80%) had addictive eating scores that were classified as severe

i.e. 6 or more YFAS symptoms out of a possible 11 (mean score 7.9 ± 2.6, range 3–11). At baseline 17% ($n = 30$) of participants reported eating disorder scores within clinical range (i.e. EDE-Q 6.0 global score of 3 or more), however did not self-report any purging behaviours. Across the three study groups, EDEQ-6.0, BES, REDX-5 and SIG scores at baseline were similar (Table 1). The secondary outcome eating behaviour scores, BMI and sex did not differ significantly between participants who completed the study and those that did not (all $p > 0.05$; see Additional file 1, Table S1). On average, non-completers were 6 years younger ($p = 0.002$) and had higher addictive eating scores than completers (mean difference of one YFAS symptom, $p = 0.020$).

Change in addictive eating behaviours

Table 2 summarises the unadjusted fitted model means and mean changes in eating behaviour scores by groups over time. Results of the changes in addictive eating are reported elsewhere [61]. In summary, from baseline to 3-months, there was a statistically significant improvement in addictive eating symptom scores in all groups with the largest mean decrease in the active intervention group. This reduction in the active intervention group was maintained from 3 to 6 months.

Change in disordered eating behaviours

Eating disorder psychopathology: There was a significant main effect of time ($F_{[2,89]}$ 20.632, $p < 0.001$), and group by time interaction effect ($F_{[4,105]}$ 3.322, $p = 0.013$) on EDE-Q global scores indicating that some groups changed more than others. From baseline to 3-months, there was a significant improvement in global EDE-Q scores in the active intervention with a mean decrease of -0.6 (95% CI: -0.8, -0.4; $p < 0.001$). The reduction was maintained with an overall mean decrease of -0.7 (95% CI: -0.9, -0.5; $p < 0.001$) from baseline to 6-months. In the passive intervention and control groups, the decrease in score from baseline to 3-months was not significant, but the overall reduction from baseline to 6-months was significant with decreases of -0.4 (95% CI: -0.7, -0.1; $p = 0.009$) and − 0.3 (95% CI: -0.5, -0.1; $p = 0.012$), respectively. Within subject changes in EDE-Q 6.0 global scores from baseline to 3-months, and from 3- to 6-months, are shown in Fig. 1.

Overall, eating concern, shape concern and weight concern EDE-Q subscale scores decreased significantly from baseline to 3-months, and 3-months to 6-months. There was a significant main effect of time on eating concern ($F_{[2,96]}$ 20.500, $p < 0.001$), shape concern ($F_{[2,86]}$ 15.934, $p < 0.001$), and weight concern ($F_{[2,89]}$ 12.424, $p < 0.001$), but not a significant group by time interaction. Mean decreases in scores from baseline to 6-months ranged from − 1.2 to -0.6 for eating concern, -1.0 to -0.3 for shape concern and − 0.7 to -0.4 for weight concern (Table 2). There were no significant main effects or interaction effects on the restraint subscale scores (all $p > 0.05$).

Binge eating

There was no significant group effect or group x time interaction on BES scores (both $p > 0.05$), but there was a significant main effect of time ($F_{[2,93]}$ 6.150, $p = 0.003$). From baseline to 3-months, the mean decrease in BES scores were − 4.0 (95% CI: -7.1, -0.8), -5.7 (95% CI: -9.5, -1.9) and − 0.0 (95% CI: -3.3, 3.2) for the active intervention, passive intervention and control groups, respectively. Overall, from baseline to 6-months, the mean decrease in BES scores were − 5.3 (95% CI: -9.0, -1.6), -4.6 (95% CI: -9.1, -0.1) and − 2.1 (%% CI: -5.8, 1.6) for the active intervention, passive intervention and control groups, respectively. There was a significant main effect of time on BES behavioural ($F_{[2,91]}$ 5.692, $p = 0.005$) and emotion ($F_{[2,95]}$ 5.978, $p = 0.004$) factor scores, but not a significant group by time interaction. Mean decreases in factor scores from baseline to 6-months ranged from − 1.0 to -2.4 for behavioural and − 1.3 to -3.0 for emotions.

Reward driven eating

There was a significant main effect of group ($F_{[2,134]}$ 4.180, $p = 0.017$), time ($F_{[2,90]}$ 24.141, $p < 0.001$) and group by time interaction effect ($F_{[4,105]}$ 4.894, $p = 0.013$) on REDX5 scores. From baseline to 3-months, there was a significant improvement in score in the active intervention and passive intervention groups with a mean decrease of -3.8 (95% CI: -4.9, -2.7; $p < 0.001$), and − 2.5 (95% CI: -3.9, -1.1; $p < 0.001$), respectively. The reductions were maintained with overall mean decreases of -4.6 (95% CI: -6.2, -2.9; $p < 0.001$) and − 2.5 (95% CI: -4.6, -0.4; $p = 0.020$) from baseline to 6-months in the active intervention and passive intervention groups, respectively. In the control group, the decreases in score from baseline to 3-months ($p = 0.364$), and 3- to 6-months ($p = 0.372$), were not significant.

General grazing

There was a significant main effect of time ($F_{[2,95]}$ 23.419, $p < 0.001$) and group by time interaction effect ($F_{[4,111]}$ 2.526, $p = 0.045$) on non-compulsive grazing scores. From baseline to 3-months, there was a significant improvement in score in the active intervention and passive intervention groups with a mean decrease of -1.4 (95% CI: -1.9, -1.0; $p < 0.001$), and − 1.1 (95% CI: -1.7, -0.5; $p = 0.001$), respectively. The reduction was maintained in the active intervention group with an overall mean decrease of -1.5 (95% CI: -2.1, -0.9; $p < 0.001$) from baseline to 6-months. In the passive intervention group, the mean decreases in non-compulsive grazing score from 3- to 6-months and baseline to 6-months were not significant. In the control

Table 1 Baseline eating behaviour scores of participants in the TRACE program randomised controlled trial ($n = 175$)

	Total sample	Active Intervention	Passive Intervention	Control	Test statistic (F or χ2)	*p*-value
	***n* = 175**	***n* = 58**	***n* = 60**	***n* = 57**		
Variable	Mean ± SD (range) or n (%)					
Total YFAS 2.0 Symptoms (/11)[a]	7.9 ± 2.6 (3–11)	8.1 ± 2.5 (3–11)	7.7 ± 2.7 (3–11)	7.9 ± 2.5 (3–11)	0.225	0.799
EDE-Q 6.0 global score[b]	2.3 ± 0.7 (0.2–4.4)	2.4 ± 0.7 (1.1–3.8)	2.3 ± 0.8 (0.2–4.4)	2.4 ± 0.7 (1.1–3.8)	0.301	0.740
EDE-Q 6.0 global score[b] >3.0					1.079	0.592
Yes	30 (17.1)	8 (13.8)	10 (16.7)	12 (21.1)		
No	145 (82.9)	50 (86.2)	50 (83.3)	45 (78.9)		
EDE-Q 6.0 subscale scores[b]						
Restraint	2.5 ± 1.5 (0.0–6.0)	2.6 ± 1.6 (0.0–6.0)	2.3 ± 1.4 (0.0–6.0)	2.7 ± 1.4 (0.0–5.6)	1.615	0.202
Eating concern	2.5 ± 1.3 (0.0–6.0)	2.5 ± 1.2 (0.4–5.2)	2.6 ± 1.4 (0.2–6.0)	2.5 ± 1.4 (0.0–6.0)	0.019	0.981
Shape concern	4.3 ± 0.9 (0.0–5.9)	4.5 ± 0.8 (2.4–5.8)	4.4 ± 1.1 (0.0–5.9)	4.1 ± 0.9 (1.9–5.8)	1.643	0.196
Weight concern	4.0 ± 0.9 (0.0–6.0)	4.0 ± 0.8 (1.6–5.6)	4.0 ± 1.0 (0.0–6.0)	3.9 ± 0.9 (1.6–5.6)	0.439	0.645
Binge Eating total score (BES)[c]	25.1 ± 8.8 (0–43)	24.8 ± 9.5 (0–43)	25.5 ± 8.1 (10–42)	24.9 ± 8.8 (2–41)	0.109	0.897
BES factor scores[c]						
Binge eating– Behavioural	11.3 ± 4.4 (0, 20)	11.1 ± 4.6 (0, 20)	11.4 ± 4.2 (4, 20)	11.2 ± 4.5 (0, 19)	0.084	0.920
Binge eating– Emotions	13.9 ± 4.9 (0, 23)	13.7 ± 5.3 (0, 23)	14.2 ± 4.6 (5, 22)	13.8 ± 4.8 (2, 22)	0.141	0.868
Binge eating severity[c]					1.300	0.861
None	35 (20.0)	11 (19.0)	13 (21.7)	11 (19.3)		
Mild to moderate	63 (36.0)	24 (41.4)	19 (31.7)	20 (35.1)		
Severe	77 (44.0)	23 (39.7)	28 (46.7)	26 (45.6)		
Reward-Based Eating (RED-X5)[d]	14.0 ± 3.3 (5–20)	13.9 ± 3.4 (5–20)	14.3 ± 3.3 (5–20)	13.7 ± 3.2 (7–20)	0.563	0.571
General 'non-compulsive' grazing (SIG)[e]	4.4 ± 1.5 (0–6)	4.5 ± 1.3 (2–6)	4.2 ± 1.5 (0–6)	4.5 ± 1.6 (0–6)	1.048	0.353
General grazing frequency[e]					10.739	0.097
None	9 (5.1)	0 (0.0)	4 (6.7)	5 (8.8)		
Mild	34 (19.4)	15 (25.9)	10 (16.7)	9 (15.8)		
Moderate	80 (45.7)	25 (43.1)	33 (55.0)	22 (38.6)		
Severe	52 (29.7)	18 (31.0)	13 (21.7)	21 (36.8)		
Loss of control 'compulsive' grazing (SIG)[e]	3.6 ± 1.6 (0–6)	3.8 ± 1.5 (1–6)	3.2 ± 1.6 (0–6)	3.8 ± 1.8 (0–6)	2.896	0.058
Loss of control grazing frequency[e]					9.223	0.061
None	24 (13.7)	6 (10.3)	10 (16.7)	8 (14.0)		
Mild	64 (36.6)	20 (34.5)	28 (46.7)	16 (28.1)		
Moderate	58 (33.1)	22 (37.9)	17 (28.3)	19 (33.3)		
Severe	29 (16.6)	10 (17.2)	5 (8.3)	14 (24.6)		

Chi squared, Fisher's Exact test or ANOVA; *$p < 0.05$

[a] YFAS 2.0, Yale Food Addiction Scale 2.0; symptom score out of 11. [b] EDE-Q 6.0, Eating Disorder Examination Questionnaire 6.0; global score out of 6, and subscale scores each out of 6. [c] BES, Binge Eating Scale; total score out of 46, score ≤ 17 = 'no binge eating', 18–26 = 'mild to moderate binge eating', ≥ 27 = 'severe binge eating'; [c] BES factor scores– Behavioural score out of 21, Emotions score out of 25; [d] RED-X5, Reward-Based Eating Drive Scale, total score out of 20; [e] SIG, Short Inventory of Grazing, severity of grazing frequency and loss of control defined as 'None' = none or less than weekly, 'Mild' = 1–3 times a week, 'Moderate' = 4–7 times a week, 'Severe' = 8 or more times a week

Table 2 Differences in eating behaviour scores by groups over time

Variable	Baseline (pre-intervention) *n* = 175	3-month (immediate post-intervention) *n* = 97	6-month (post-intervention follow-up) *n* = 79	Mean difference baseline to 3-months	Mean difference 3- to 6-months	Mean difference baseline to 6- months	Group x time (*p*-value)
	Mean ± SE (95% CI)						
Addictive eating (YFAS 2.0 symptom score / out of 11)							< 0.001
Active	8.1 ± 0.3 (7.4, 8.7)	3.3 ± 0.5 (2.3, 4.4)	3.5 ± 0.7 (2.3, 4.4)	-4.7 ± 0.5 (-5.8, -3.6)	0.1 ± 0.5 (-0.9, 1.2)	-4.5 ± 0.7 (-5.9, -3.3)	
Passive	7.7 ± 0.3 (7.1, 8.4)	4.0 ± 0.7 (2.7, 5.4)	5.6 ± 0.8 (4.0, 7.2)	-3.7 ± 0.7 (-5.0, -2.4)	1.6 ± 0.7 (0.2, 2.9)	-2.1 ± 0.8 (-3.7, -0.6)	
Control	7.9 ± 0.3 (7.2, 8.5)	6.3 ± 0.6 (5.2, 7.4)	4.7 ± 0.6 (3.4, 5.9)	-1.5 ± 0.6 (-2.6, -0.4)	-1.7 ± 0.5 (-2.7, -0.7)	-3.2 ± 0.6 (-4.5, -1.9)	
Eating disorder global score (EDE-Q 6.0 global score / out of 6)							0.013
Active	2.4 ± 0.1 (2.2, 2.6)	1.8 ± 0.1 (1.5, 2.0)	1.7 ± 0.1 (1.4, 2.0)	-0.6 ± 0.1 (-0.8, -0.4)	-0.1 ± 0.1 (-0.4, 0.2)	-0.7 ± 0.1 (-0.9, -0.5)	
Passive	2.3 ± 0.1 (2.1, 2.5)	2.1 ± 0.2 (1.8, 2.4)	1.9 ± 0.2 (1.5, 2.2)	-0.2 ± 0.1 (-0.5, 0.1)	-0.2 ± 0.2 (-0.6, 0.1)	-0.4 ± 0.2 (-0.7, -0.1)	
Control	2.3 ± 0.1 (2.2, 2.5)	2.3 ± 0.1 (2.0, 2.5)	2.0 ± 0.1 (1.8, 2.3)	-0.1 ± 0.1 (-0.3, 0.1)	-0.2 ± 0.1 (-0.4, 0.0)	-0.3 ± 0.1 (-0.5, -0.1)	
Eating disorder subscale scores (EDE-Q 6.0 subscale scores / out of 6)							
Restraint							0.123
Active	2.6 ± 0.2 (2.2, 3.0)	2.1 ± 0.2 (1.6, 2.6)	2.0 ± 0.3 (1.5, 2.5)	-0.5 ± 0.2 (-1.0, -0.0)	-0.1 ± 0.3 (-0.6, 0.5)	-0.6 ± 0.3 (-1.1, -0.1)	
Passive	2.3 ± 0.2 (1.9, 2.6)	2.7 ± 0.3 (2.1, 3.3)	2.0 ± 0.3 (1.4, 2.6)	0.5 ± 0.3 (-0.1, 1.1)	-0.7 ± 0.3 (-1.4, -0.1)	-0.2 ± 0.2 (-0.7, 0.3)	
Control	2.7 ± 0.2 (2.3, 3.1)	2.8 ± 0.3 (2.3, 3.3)	2.5 ± 0.2 (2.0, 3.0)	0.0 ± 0.2 (-0.4, 0.5)	-0.2 ± 0.3 (-0.7, 0.3)	-0.2 ± 0.2 (-0.7, 0.3)	
Eating concern							0.090
Active	2.5 ± 0.2 (2.2, 2.9)	1.4 ± 0.2 (1.0, 1.8)	1.4 ± 0.3 (0.9, 1.9)	-1.1 ± 0.2 (-1.5, -0.7)	-0.0 ± 0.2 (-0.5, 0.4)	-1.2 ± 0.3 (-1.7, -0.7)	
Passive	2.6 ± 0.2 (2.2, 2.9)	1.9 ± 0.3 (1.4, 2.4)	1.8 ± 0.3 (1.2, 2.4)	-0.7 ± 0.3 (-1.2, -0.2)	-0.1 ± 0.3 (-0.7, 0.5)	-0.8 ± 0.3 (-1.4, -0.2)	
Control	2.5 ± 0.2 (2.2, 2.9)	2.2 ± 0.2 (1.8, 2.6)	2.0 ± 0.2 (1.5, 2.4)	-0.3 ± 0.2 (-0.7, 0.1)	-0.3 ± 0.2 (-0.7, 0.2)	-0.6 ± 0.2 (-1.0, -0.1)	
Shape concern							0.072
Active	4.5 ± 0.1 (4.2, 4.7)	3.7 ± 0.2 (3.3, 4.1)	3.4 ± 0.2 (3.0, 3.9)	-0.8 ± 0.2 (-1.1, -0.4)	-0.2 ± 0.2 (-0.6, 0.1)	-1.0 ± 0.2 (-1.4, -0.6)	
Passive	4.4 ± 0.1 (4.1, 4.6)	3.8 ± 0.2 (3.3, 4.2)	3.6 ± 0.3 (3.0, 4.2)	-0.6 ± 0.2 (-1.0, -0.2)	-0.2 ± 0.2 (-0.6, 0.3)	-0.8 ± 0.3 (-1.3, -0.2)	
Control	4.1 ± 0.1 (3.9, 4.4)	4.1 ± 0.2 (3.7, 4.5)	3.8 ± 0.2 (3.3, 4.2)	-0.1 ± 0.2 (-0.4, 0.3)	-0.3 ± 0.2 (-0.6, 0.0)	-0.3 ± 0.2 (-0.8, 0.0)	
Weight concern							0.502
Active	4.0 ± 0.1 (3.7, 4.2)	3.4 ± 0.2 (3.1, 3.8)	3.3 ± 0.2 (2.9, 3.7)	-0.5 ± 0.2 (-0.9, -0.2)	-0.1 ± 0.2 (-0.5, 0.2)	-0.7 ± 0.2 (-1.1, -0.3)	
Passive	4.0 ± 0.1 (3.8, 4.3)	3.6 ± 0.2 (3.2, 4.1)	3.4 ± 0.3 (2.9, 3.9)	-0.4 ± 0.2 (-0.8, -0.0)	-0.2 ± 0.2 (-0.7, 0.2)	-0.6 ± 0.2 (-1.1, -0.2)	
Control	3.9 ± 0.1 (3.6, 4.1)	3.7 ± 0.2 (3.3, 4.1)	3.5 ± 0.2 (3.1, 3.9)	-0.2 ± 0.2 (-0.5, 0.1)	-0.2 ± 0.2 (-0.5, 0.1)	-0.4 ± 0.2 (-0.7, 0.0)	
Binge Eating (BES score / out of 46)							0.090
Active	24.8 ± 1.2 (22.5, 27.1)	20.9 ± 1.4 (18.1, 23.3)	19.5 ± 1.7 (16.1, 22.9)	-4.0 ± 1.6 (-7.1, -0.8)	-1.3 ± 1.1 (-3.5, 0.8)	-5.3 ± 1.9 (-9.0, -1.6)	
Passive	25.5 ± 1.1 (23.3, 27.8)	19.9 ± 1.8 (16.3, 23.4)	20.9 ± 2.2 (16.7, 25.2)	-5.7 ± 1.9 (-9.5, -1.9)	1.1 ± 1.4 (-1.7, 3.9)	-4.6 ± 2.3 (-9.1, -0.1)	
Control	24.9 ± 1.2 (22.6, 27.3)	24.9 ± 1.4 (22.1, 27.8)	22.8 ± 1.7 (19.5, 26.2)	-0.0 ± 1.6 (-3.3, 3.2)	-2.1 ± 1.0 (-4.1, -0.1)	-2.1 ± 1.9 (-5.8, 1.6)	
Binge Eating factors							
Binge eating - Behavioural (BES factor score / out of 21)							0.167

Table 2 (continued)

Variable	Baseline (pre-intervention) *n* = 175	3-month (immediate post-intervention) *n* = 97	6-month (post-intervention follow-up) *n* = 79	Mean difference baseline to 3-months	Mean difference 3- to 6-months	Mean difference baseline to 6- months	Group x time (*p*-value)
Active	11.1 ± 0.6 (10.0, 12.3)	9.7 ± 0.7 (8.3, 11.1)	8.7 ± 0.8 (7.0, 10.3)	-1.4 ± 0.8 (-3.0, 0.2)	-1.0 ± 0.6 (-2.3, 0.2)	-2.4 ± 0.9 (-4.2, -0.6)	
Passive	11.4 ± 0.6 (10.3, 12.7)	8.8 ± 0.9 (7.1, 10.6)	9.2 ± 1.0 (7.1, 11.2)	-2.6 ± 0.9 (-4.5, -0.7)	0.4 ± 0.8 (-1.2, 1.9)	-2.3 ± 1.1 (-4.4, -0.1)	
Control	11.2 ± 0.6 (10.1, 12.4)	11.4 ± 0.7 (10.0, 12.8)	10.2 ± 0.8 (8.6, 11.8)	0.1 ± 0.8 (-1.5, 1.7)	-1.1 ± 0.5 (-2.2, -0.0)	-1.0 ± 0.9 (-2.8, 0.8)	
Binge eating - Emotions (BES factor score / out of 25)							0.177
Active	13.7 ± 0.6 (12.5, 15.0)	11.2 ± 0.8 (9.5, 12.8)	10.8 ± 1.0 (8.8, 12.7)	-2.6 ± 1.0 (-4.5, -0.7)	-0.4 ± 0.7 (-1.7, 1.0)	-3.0 ± 1.1 (-5.2, -0.8)	
Passive	14.2 ± 0.6 (12.9, 15.4)	11.0 ± 1.0 (8.9, 13.0)	11.7 ± 1.3 (9.2, 14.2)	-3.2 ± 1.2 (-5.5, -0.9)	0.7 ± 0.9 (-1.0, 2.5)	-2.5 ± 1.3 (-5.1, 0.2)	
Control	13.8 ± 0.6 (12.5, 15.1)	13.5 ± 0.8 (11.9, 15.2)	12.5 ± 1.0 (10.6, 14.5)	-0.2 ± 1.0 (-2.2, 1.7)	-1.0 ± 0.6 (-2.2, 0.2)	-1.3 ± 1.1 (-3.4, 1.0)	
Reward-Based Eating (RED-X5 score / out of 20)							0.001
Active	13.9 ± 0.4 (13.0, 14.7)	10.1 ± 0.6 (8.9, 11.3)	9.3 ± 0.9 (7.5, 11.1)	-3.8 ± 0.5 (-4.9, -2.7)	-0.8 ± 0.8 (-2.3, 0.7)	-4.6 ± 0.9 (-6.2, -2.9)	
Passive	14.3 ± 0.4 (13.5, 15.1)	11.8 ± 0.7 (10.3, 13.3)	11.8 ± 1.1 (9.6, 14.0)	-2.5 ± 0.7 (-3.9, -1.1)	0.0 ± 1.0 (-1.9, 1.9)	-2.5 ± 1.1 (-4.6, -0.4)	
Control	13.7 ± 0.4 (12.8, 14.5)	13.2 ± 0.6 (12.0, 14.4)	12.5 ± 0.8 (10.9, 14.2)	-0.5 ± 0.6 (-1.6, 0.6)	-0.6 ± 0.7 (-2.0, 0.8)	-1.1 ± 0.8 (-2.7, 0.5)	
General 'non-compulsive' grazing (SIG score / out of 6)							0.045
Active	4.5 ± 0.2 (4.1, 4.9)	3.1 ± 0.2 (2.6, 3.5)	3.0 ± 0.3 (2.4, 3.6)	-1.4 ± 0.2 (-1.9, -1.0)	-0.1 ± 0.3 (-0.6, 0.5)	-1.5 ± 0.3 (-2.1, -0.9)	
Passive	4.2 ± 0.2 (3.8, 4.5)	3.0 ± 0.3 (2.4, 3.6)	3.4 ± 0.4 (2.7, 4.2)	-1.1 ± 0.3 (-1.7, -0.5)	0.4 ± 0.4 (-0.3, 1.1)	-0.7 ± 0.4 (-1.4, 0.0)	
Control	4.5 ± 0.2 (4.1, 4.8)	4.0 ± 0.2 (3.5, 4.5)	3.8 ± 0.3 (3.3, 4.4)	-0.5 ± 0.3 (-1.0, 0.0)	-0.2 ± 0.3 (-0.7, 0.3)	-0.7 ± 0.3 (-1.2, -0.1)	
Loss of control 'compulsive' grazing (SIG score / out of 6)							0.001
Active	3.8 ± 0.2 (3.4, 4.2)	1.9 ± 0.3 (1.4, 2.4)	2.0 ± 0.3 (1.3, 2.6)	-1.8 ± 0.3 (-2.4, -1.3)	0.1 ± 0.3 (-0.5, 0.6)	-1.8 ± 0.3 (-2.4, -1.1)	
Passive	3.2 ± 0.2 (2.7, 3.6)	2.1 ± 0.3 (1.4, 2.7)	2.6 ± 0.4 (1.8, 3.4)	-1.1 ± 0.3 -1.7, -0.4)	0.5 ± 0.37 (-0.2, 1.3)	-0.5 ± 0.4 (-1.3, 0.3)	
Control	3.8 ± 0.2 (3.3, 4.2)	3.5 ± 0.3 (3.0, 4.0)	3.0 ± 0.3 (2.3, 3.6)	-0.3 ± 0.3 (-0.8, 0.3)	-0.5 ± 0.3 (-1.1, -0.0)	-0.8 ± 0.3 (-1.4, -0.2)	

Linear Mixed Models fitting addictive eating, mental health variables as the dependent variable, time measurement, intervention group, and interaction between time and group term as fixed effect. YFAS 2.0, Yale Food Addiction Scale; EDE-Q 6.0, Eating Disorder Examination Questionnaire 6.0; BES, Binge Eating Scale; RED-X5, Reward-Based Eating Drive Scale; SIG, Short Inventory of Grazing

group, the decrease in scores from baseline to 3-months and 3- to 6-months were not significant, but the overall reduction from baseline to 6-months was significant with a decrease of -0.7 (95% CI: -1.2, -0.1; $p = 0.022$).

Grazing accompanied by a sense of loss of control

There was a significant main effect of group ($F_{[2,130]}$ 4.857, $p = 0.009$), time ($F_{[2,94]}$ 20.934, $p < 0.001$) and group by time interaction effect ($F_{[4,110]}$ 4.864, $p = 0.001$) on compulsive grazing scores. From baseline to 3-months, there was a significant improvement in score in the active intervention and passive intervention groups with a mean decrease of -1.8 (95% CI: -2.4, -1.3; $p < 0.001$), and – 1.1 (95% CI: -1.7, -0.4; $p = 0.002$), respectively. The reduction was maintained in the active intervention group with an overall mean decrease of -1.8 (95% CI: -2.4, -1.1; $p < 0.001$) from baseline to 6-months. In the passive intervention group, the mean decreases in non-compulsive grazing scores from baseline to 6-months were not significant. In the control group, the decrease in compulsive grazing score from baseline to 3-months was not significant, but the decrease in score from 3 to 6-months was significant with an overall decrease of -0.8 (95% CI: -1.4, -0.2; $p = 0.010$) from baseline to 6-months.

After adjusting for BMI, the main effects and group by time interactions on eating behaviour scores remained significant [see Additional file 1, Table S2 and S3, Figure S1]. The overall pattern of change and magnitude of results remained similar to the unadjusted models for all groups at each timepoint. The complete case

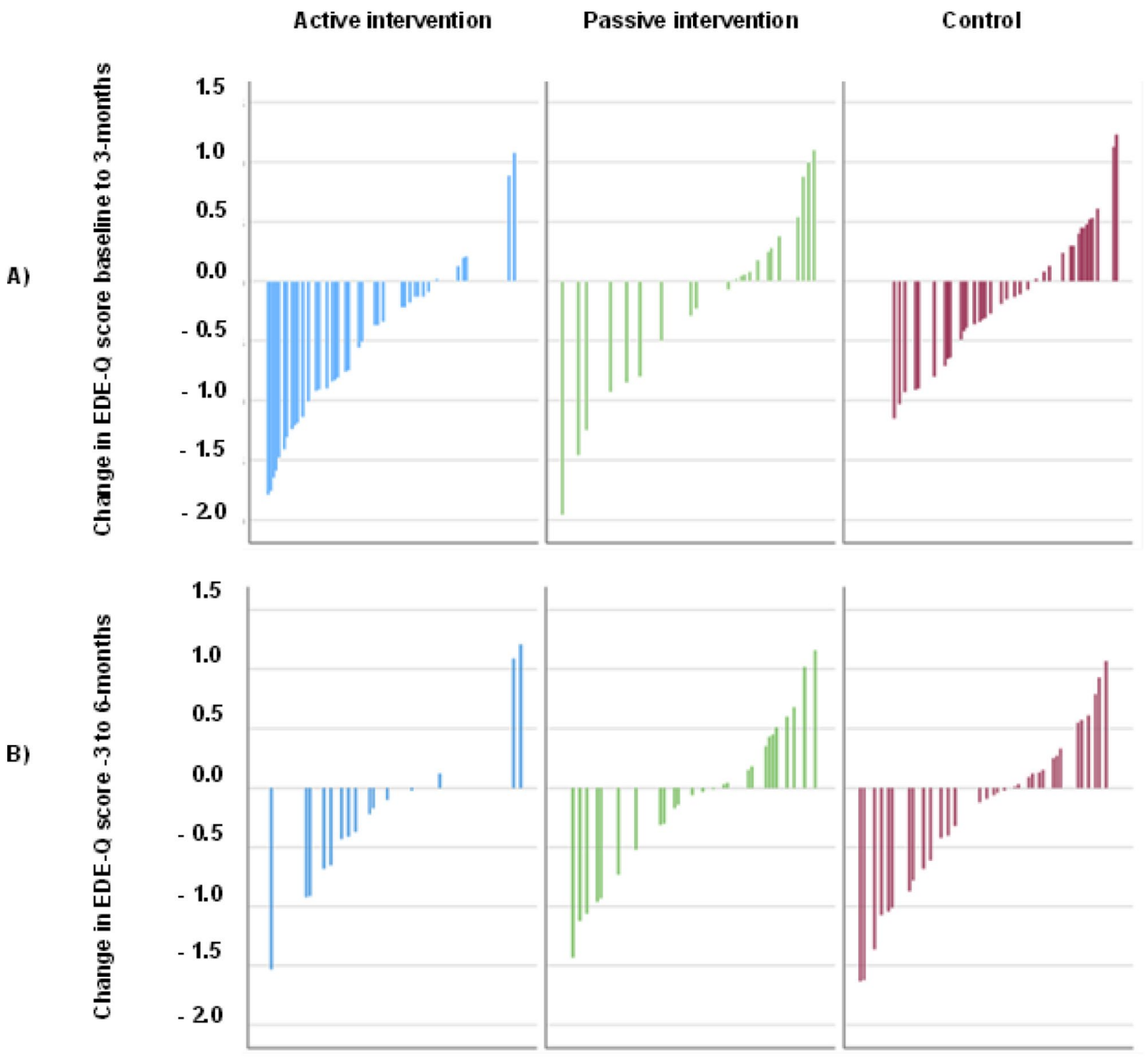

Fig. 1 Change in Eating Disorder Examination Questionnaire 6.0 (EDE-Q) global scores. Change in scores for individual participants, by group, enrolled in the TRACE RCT at **A**) 3-months follow-up ($n = 97$), and **B**) 6-months follow-up ($n = 79$). A decrease in score indicates an improvement in eating disorder psychopathology

analysis showed a similar overall pattern and magnitude of results in comparison to the ITT analysis from baseline to 3-months, and 3-months to 6-months [see Additional file 1, Table S4]. The exception being the change in EDE-Q 6.0 weight concern subscale score from baseline to 3-months in the passive intervention group. While the ITT analysis showed a significant decrease in weight concern score from baseline to 3-months in the passive intervention group [-0.4 (95% CI: -0.8, -0.0; $p = 0.036$)], this decrease in subscale score was not significant in the complete case analyses [-0.3 (95% CI: -0.7, 0.2; $p = 0.304$)].

Associations between changes in addictive eating and disordered eating behaviours

With the exception of EDE-Q subscale score for dietary restraint, the change in YFAS scores was positively associated with the change in disordered eating behaviour scores at 3-months (small to moderate correlations, Table 3) indicating that as addictive eating symptoms decreased the severity of eating disorder psychopathology, binge eating, reward driven eating and grazing also decreased. Scatter plots for each outcome are presented in Additional file 1(Figures S3.A-J).

Table 3 Spearman's rank correlation analysis between the change in addictive eating symptoms and the change in disordered eating behaviour outcomes from pre-intervention to immediate post-intervention (3-months follow-up, $n = 97$)

Disordered eating behaviour change score	Addictive eating behaviour change score (YFAS symptom score)
EDE-Q 6.0 Global score	0.46**
EDE-Q 6.0 Dietary restraint	0.89
EDE-Q 6.0 Eating concern	0.53**
EDE-Q 6.0 Weight concern	0.23*
EDE-Q 6.0 Shape concern	0.40**
BES	0.69**
BES Behavioural	0.41**
BES Emotions	0.40**
RED-X5	0.58**
SIG General grazing	0.39**
SIG Grazing with loss of control	0.53**

*$p < 0.05$, **$p < 0.001$

YFAS 2.0, Yale Food Addiction Scale; EDE-Q 6.0, Eating Disorder Examination Questionnaire 6.0; BES, Binge Eating Scale; RED-X5, Reward-Based Eating Drive Scale; SIG, Short Inventory of Grazing

Changes in BMI

There was a significant main effect of time ($F_{[2,89]}$ 20.632, $p < 0.001$) on BMI, but not a significant group by time interaction, which is interpreted as the change in BMI over time for all three groups was similar. From baseline to 3-months, the changes being – 0.9 (95% CI: -1.6, -0.1), -0.7 (95% CI: -1.7, 0.2), and – 0.0 (95% CI: -0.8, 0.7) for the active intervention, passive intervention and control groups, respectively; and from 3- to 6-months, – 0.5 (95% CI: -1.4, 0.3), 0.1 (95% CI: -0.9, 1.2), and – 0.2 (95% CI: -1.0, 0.6), for the active intervention, passive intervention and control groups, respectively (see Additional file 1 Figure S2.).

Discussion

The main objective of the current study was to explore the effect of the TRACE intervention on disordered eating behaviour outcomes in adults with addictive eating. Findings suggest that the dietitian-led telehealth program had a positive effect on disordered eating behaviour symptoms. Significant improvements in scores for eating disorder psychopathology, reward-based eating, compulsive and non-compulsive grazing were found following the 3-month trial in the active intervention compared to the control group. The passive intervention also demonstrated a beneficial effect on disordered eating behaviours. Although no significant between group differences were found in binge eating, there were significant decreases in binge eating scores over time in both the active and passive intervention groups. Potentially, the BES may not be as sensitive to change as the other measures used in the study. It should also be noted that study was powered with addictive eating as the main outcome, therefore the study may not be statistically powered to detect a change in all outcome variables. To our knowledge this is the first intervention study in individuals with addictive eating with a weight neutral approach that captures a range of disordered eating outcomes, and the findings will be useful for the field moving forward.

In the current study, adults with addictive eating reported higher weight and greater severity of eating disorder psychopathology at baseline compared to previous research in general population samples (for example [77–81]). Though EDE-Q scores were lower than previous data for clinical samples with eating disorder diagnoses and among individuals seeking treatment for obesity (mean EDE-Q score of 2.3 ± 0.7 in the current study sample vs. general population norm 0.9 ± 0.9 vs. clinical norm 4.0 ± 1.3 vs. population with obesity norm 2.8 ± 1.0 vs.) [77]. This suggests that individuals with addictive eating may have greater weight and dieting concerns than the general population. Therefore, it is important that interventions designed for individuals with addictive eating do not elevate risk of disordered eating attitudes and behaviours.

The TRACE intervention which used a harm reduction rather than an abstinence based approach, and a weight neutral focus, was shown to be consistent with existing research indicating that weight neutral approaches are of benefit within management of eating disorders in individuals of higher body weight [82, 83]. Importantly, with the harm reduction approach taken by the intervention, there was no significant increase in dietary restraint. Restriction is one element of disordered eating that warrants concern as restrictive practices in those with eating disorder vulnerabilities can lead to increased problematic eating behaviours, particularly binge eating, and eating disorder diagnoses in some individuals [84]. Further, dietary restraint is of interest in treatments for individuals with higher weight. As a result of weight management education, it would be anticipated that treatment approaches would lead to an increase in restraint scores as individuals attempt to make changes that reduce consumption of particular foods, but not at levels that warrant concern or indicate an eating disorder. This is an important consideration in the development of disordered eating interventions, particularly as treatments for addictive eating evolve [35]. Dietary restriction and other problematic eating disorder behaviours as studied in this paper need to be monitored closely. Given some individuals participating in the current study had high baseline scores on the EDEQ and BES, management approaches or new interventions for addictive eating could be better delivered under the guidance of health professionals, rather than individuals relying on online self-help alternatives.

A second objective of the current study was to examine the association between addictive eating symptoms and disordered eating outcomes from pre- to post-treatment. While addictive eating demonstrates some overlap with eating disorders, the TRACE intervention was NOT designed for the treatment of eating disorders, but targeted addictive eating which is under consideration for similarities with eating disorder or substance use disorders [85]. Findings from the current study suggest that problematic overeating behaviours are positively corelated. For example, changes in addictive eating symptoms were moderately correlated with other eating disorder psychopathologies (i.e., eating, weight and shape concern), reward-based eating and binge eating. Given the previous associations between addictive eating and binge eating [8, 59], it was not surprising that many individuals seeking treatment for addictive eating in the current study scored highly on the BES. Similar to previous research in a cross-sectional sample of adults with food addiction, the BES factors (1) emotions related to binge eating and (2) behavioral manifestations of binge eating, were associated with addictive eating. The role of different facets of binge eating is of particular interest in understanding individual's lived experience of addictive eating. Of note, the BES like other tools in the current study is a self-report measure and is not diagnostic of binge eating disorder. Considering the overall eating behaviour scores in the current study, future interventions for addictive eating warrant monitoring for eating disorder psychopathology which aligns with current practise guidelines for the management of eating disorders in individuals with higher weight [31]. Further if disordered eating behaviors are correlated, the perception of loss of control, which is not routinely assessed, may be the distinction between 'healthy' and 'disordered' eating behaviors. This is an important element to consider in future studies, as it is a core symptom of several eating disorders and can be associated with different eating episodes regardless of the amount of food consumed [86].

A strength of the current study is that disordered eating behaviours and outcomes were assessed and reported as part of the management intervention for addictive eating. This is novel, and a highly important aspect in this area of research, as existing reviews of addictive eating interventions [35, 36, 42] indicate that these outcomes are generally not considered. The exploratory findings warrant future investigations as outcomes in other treatment modalities are being trialled in the field of addictive eating. The findings of this study should be interpreted in consideration of the following potential limitations. Firstly, participants were not blinded to the intervention, and this may have biased reporting of their eating behaviours. The significant differences in the changes in scores from baseline to 6-months do not suggest a relevant bias. At follow-up time points, the rates of missing data were different between groups, and the number of participants in the intervention and control groups are relatively small. The results may not be generalisable to all population groups given the predominantly female sample; and the exclusion of individuals with BMI < 18.5 kg/m^2 and those with purging behaviours. Although the presence of eating disorder diagnoses via a clinical interview were not assessed, this measure was undertaken to reduce the likelihood of recruiting participants with at-risk restrictive eating practices and those who may be at risk of an eating disorder and are medically compromised. While there is robust support for the reliability and validity of the EDE-Q in the assessment of eating disorder symptoms [87], concerns have been raised regarding the validity of the four theorised subscales of the EDE-Q [77, 87]. This should be considered when interpreting the subscale results. Lastly, adjustment for multiple comparisons was not carried out due to the exploratory nature of this secondary analyses, therefore the chance of Type-1 errors may be increased. However, it should be noted that if an adjusted significance level were to be applied (e.g. Bonferroni correction) the majority of findings remain significant.

Conclusion

The dietitian-led TRACE intervention which adopted a weight-neutral, harm reduction approach for the management of addictive eating in adults demonstrated positive effects on some co-occurring disordered eating behaviours. Importantly the intervention did not cause any adverse changes in the eating disorder pathologies measured. The findings suggest that the successful management of addictive eating behaviours may also "transfer" to, and help change, other disordered eating behaviours. If individuals are able to successfully self-regulate these behaviors, and these effects are sustainable, this could have a lasting impact on health. Future studies with preplanned hypotheses are needed to confirm the observed findings.

Abbreviations

ANOVA	Analysis of variance
BES	Binge Eating Scale
BMI	Body Mass Index
CBT-E	Cognitive behaviour therapy– enhanced
CI	Confidence interval
CONSORT	Consolidated Standards of Reporting Trials
DSM-5	Diagnostic and Statistical Manual of Mental Disorders 5th Edition
EDE-Q 6.0	Eating Disorder Examination Questionnaire 6.0
ICD	International Classification of Diseases
ITT	Intention-to-treat
RCT	Randomised controlled trial
RED-X5	Reward-Based Eating Drive Scale – 5
SD	Standard deviation
SE	Standard error
SIG	Short Inventory of Grazing

TRACE	Targeted Research for Addictive and Compulsive Eating
YFAS 2.0	Yale Food Addiction Scale 2.0

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40337-025-01241-x.

Supplementary Material 1: Supplementary information presented in Additional file 1 includes analysis of baseline data for study completers vs. non-completers (Table S1), the intention-to-treat analysis with adjustment for BMI (Table S2, S3 and Figure S1), change in BMI by groups over time (Figure S2), the complete case analyses (Table S4), and scatter plots from the Spearman's rank correlation analyses conducted.

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Author contributions
All authors had a substantial role in the conception and design of the study. JAS conducted the data analysis and prepared the original draft of the manuscript. ML, MW, PJH, SJP, CEC and TLB contributed to the interpretation of the data analyses. All authors contributed to the writing and provided critical revision of the manuscript. All authors read and approved the final manuscript.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
Approval to conduct this study was obtained from the University of Newcastle Human Research Ethics Committee (H-2021-0100) and was prospectively registered with Australian New Zealand Clinical Trials Register (ACTRN12621001079831) and follows the CONSORT reporting guidelines for Randomized Trials of Nonpharmacologic Treatments. Informed consent was obtained from all individuals who participated in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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