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Reduction in eating disorder symptoms among adults in different weight loss interventions

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Abstract

Restriction of food intake and counting calories as part of weight loss programs are thought to trigger eating behaviors and attitudes which can lead to eating disorders. We have developed a treatment model, regulation of cues (ROC), that targets appetitive traits, including food responsiveness and satiety responsiveness, which could address overeating at an implicit level and reduce risk of detrimental behaviors and attitudes. This manuscript evaluates eating disorder symptoms, attitudes, and behaviors among adults with overweight or obesity randomized to ROC, behavioral weight loss (BWL), a combination of ROC+BWL (ROC+) and an active comparator (AC). Participants included 271 adults with a body mass index of 25 to 45, age 18 to 65 years, and a lack of comorbidities that could interfere with participation. Assessments occurred at baseline, mid-treatment (6 months), post-treatment (12-months) and 6- and 12-month follow-up. During treatment, participants in all four arms showed decreases in Eating, Weight, and Shape concerns on the Eating Disorder Examination-Questionnaire and binge eating symptoms on the Binge Eating Scale which were maintained at 6-month follow-up but increased at the 12-month follow-up. Both the ROC+ and BWL arms showed increases in Restraint during treatment which dissipated after treatment ended. This study contributes to a growing body of literature demonstrating that weight loss programs are not associated with increases in eating disorder symptoms. Future studies should evaluate interventions to maintain improvements in eating disorder symptoms following weight loss programs.

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Introduction

Both eating disorders and obesity have significant health and psychological consequences. [1-3] Although often treated as separate conditions, emerging evidence suggests that individuals with overweight or obesity (OW/OB) have high rates of disordered eating and eating disorders.[4-8] In a US population representative sample, individuals with OB had higher lifetime rates and past-12-month rates of eating disorder diagnoses (bulimia nervosa and binge eating disorder) than their healthy weight counterparts.[6] Additionally, the risk of eating disorder diagnosis increased with increasing obesity status. This is concerning, as individuals who have both OB and an eating disorder diagnosis are at greater risk for exacerbated physical and psychological health issues than individuals with either condition alone.[9,10]

Behavioral weight loss (BWL) is considered the most effective treatment for individuals with OW/OB.[11] BWL provides psychoeducation about energy intake (including restricting caloric intake) and physical activity along with behavior therapy skills. Behavior therapy skills include self-monitoring food, calories, and physical activity, stimulus control, problem solving, cognitive restructuring, stress management and goal setting. Current evidence is mixed regarding the impact of BWL interventions on eating disorder symptoms. In a weight loss study in post-menopausal women, the intervention group showed reductions in binge eating, uncontrolled eating, and emotional eating, and increases in restrained eating.[12] Large studies such as the LookAHEAD trial suggest that BWL decreased binge eating disorder symptoms among individuals with type 2 diabetes and OW/OB.[13] However, among veterans receiving BWL, high frequency binge eating predicted weight gain,[14] and in another program, greater dietary restraint resulted in increased binge eating while greater self-reported restraint behavior resulted in decreased binge eating and greater weight loss during the trial.[15]

There are concerns that the caloric self-monitoring which is a cornerstone of BWL programs could contribute to the development of maladaptive eating cognitions and behaviors.[16,17] BWL guidelines to restrict caloric intake and increase physical activity are thought to potentially provoke pre-existing maladaptive processes in those at risk. These concerns are founded on the dietary restraint theory, which suggests that dietary restraint can lead to the development of eating disorders.[18,19] However, to date, prospective risk factor studies have not consistently supported the concept that dietary restraint alone is sufficient to lead to an eating disorder,[20] and the factors that contribute to the development of eating disorders are considered heterogeneous and complex.[21,22]

In contrast to weight loss programs that reduce intake through caloric self-monitoring, we have developed a novel weight loss model called Regulation of Cues (ROC), which is based on the behavioral susceptibility theory of obesity (BST).[23-25] The BST states that genetically determined appetitive traits, including satiety responsiveness and food responsiveness, interact with the current food environment and contribute to increased eating behavior and weight gain. The ROC program is substantially different than BWL as the focus is on experiential learning to increase satiety responsiveness (SR) and decrease food responsiveness (FR).[26] Specifically, ROC includes appetite awareness training [27,28] to

increase SR and cue-exposure treatment to decrease FR and improve inhibition of urges to overeat.[29] Our recent randomized controlled trial compared four arms; ROC, BWL, ROC combined with BWL (ROC+) and an Active Comparator (AC) and showed that ROC could be considered an alternative model to BWL in terms of weight loss and maintenance.[30] No other treatment models combine the unique components of ROC and at this time, there are no data regarding the impact of the ROC program on eating disorder symptoms.

In this secondary data analyses, we sought to explore the impact of the components of ROC and BWL on eating disorder symptoms during and 12-months after treatment. We hypothesized that the treatment arms including instructions to restrict caloric intake (i.e., BWL and ROC+) would result in increased Restraint as compared to arms with no caloric restriction (i.e., ROC and AC). We also hypothesized that the three active treatment groups (i.e., BWL, ROC, and ROC+) would result in decreased Eating, Shape, and Weight Concern as well as binge eating symptoms as compared to AC. We also hypothesized that ROC would result in decreased Eating, Shape and Weight Concern and binge eating symptoms as compared to BWL.

Methods

Study Design

The Providing Adult Collaborative Interventions for Ideal Changes (PACIFIC) study (Clinical Trial NCT02516839) was a randomized clinical trial conducted at the Center for Healthy Eating and Activity Research at the University of California San Diego (UC San Diego). Study design, recruitment methods, measures, participant characteristics, and study outcomes are detailed in full in previous publications.[29,30] PACIFIC was a 4-arm parallel design trial in which participants were randomized to 1 of 4 group interventions: ROC, BWL, ROC+, or AC. Participants completed assessment visits at baseline, mid-treatment (6 months), post-treatment (12-months) and 6- and 12-month follow-up. Written consent was obtained from all participants and the study protocol was approved by the Institutional Review Board at UC San Diego (151110).

Participants

Participants were recruited from the San Diego, California area and inclusion criteria included adults aged 18-65 years of age, body mass index (BMI) 25 and 45 kg/m^2, English language skills of at least the fifth-grade reading level, and willingness to participate in assessment and treatment visits. Exclusionary criteria included history of diagnosis of a serious current physical disease (e.g., diabetes), any medical condition that would make physical activity unsafe, current substance abuse, pregnancy, lactation, and any medical or psychological problems that could make adherence to the study protocol difficult or dangerous.

Intervention

All randomized participants attended 26 90-minute group treatments over 12 months. All four treatment groups provided the same physical activity goal of engaging in at least 150 minutes of moderate-to-vigorous intensity activity per week and achieving at least

10,000 steps per day. The three active treatment groups (ROC, BWL, and ROC+) were provided pedometers and encouraged to self-monitor physical activity. Brief descriptions of the treatment groups are included below and further details regarding the intervention arms have been published.[29]

Regulation of Cues (ROC).—ROC targeted increasing SR and decreasing FR through experiential learning exercises. Participants were taught about hunger and satiety dysregulation (appetite awareness training) and were instructed to self-monitor their hunger before, during, and after each meal. Participants brought dinner to groups and monitored their hunger in-session while simulating different contexts. After building on this skill, participants learned to self-monitor cravings and urges to eat. Participants completed in-session exposures to highly craved foods (cue-exposure treatment) and self-monitored cravings outside of the group treatment. Participants were instructed to self-monitoring hunger, cravings and physical activity on paper or using an app.

Behavioral Weight Loss.—The BWL program recommended a balanced deficit diet based on the US Department of Agriculture's MyPlate guidelines.[31] Participants were provided nutrition and physical activity education, and individualized calorie goals were given to promote a weight loss of 1 to 2 pounds per week. Participants were taught behavior change skills and instructed to self-monitor their food intake, caloric intake, and physical activity on paper or using an app.

Combined Program (ROC+).—The ROC+ group integrated the focus on diet and energy intake from BWL with the ROC program. Participants in this group were taught to self-monitor hunger, cravings, food intake, caloric intake, physical activity, and step counts either on paper or using an app.

Active Comparator (AC).—The AC program included psychoeducation about diet, stress management, and social support. At each session, a mindfulness exercise was conducted, and participants were encouraged to practice mindfulness at home. Participants were not instructed to self-monitor.

Measures

Measures occurred at baseline (month 0), mid-treatment (month 6), post-treatment (month 12), 6-month follow-up (month 18) and 12-month follow-up (month 24). Participants self-reported demographic information including age, gender, and race/ethnicity as part of the baseline assessment. Race and ethnicity questions were used to classify participants as Hispanic, White and Non-Hispanic Other Races. BMI (weight in kg/height in m^2) and physical activity measured with the seven-day Physical Activity Recall (PAR[32]) were included as planned covariates.

Eating Disorder Examination Questionnaire (EDE-Q; version 6.0) [33].—The EDE-Q is a questionnaire adaptation of the Eating Disorder Examination interview that assessed eating disorder attitudes and behaviors at each assessment time point. The EDE-Q is a 28-item instrument with 4 subscales: Restraint, Eating Concern, Weight Concern, and

Shape Concern. The EDE-Q has strong psychometric properties.[34,35] A cut-off of 4 (on any of four subscales and/or global score) is used to classify individuals within the clinical range.[36,37]

Binge Eating Scale (BES).[38]—The BES is a 16-item self-report questionnaire that assessed binge eating severity in a continuous manner at each assessment time point. The BES summed score is a unidimensional scale, with higher scores indicative of greater severity of binge eating behavior. The BES demonstrates validity in identifying loss of control overeating but is less precise at differentiating between large or small amounts of food.[39] A score of 18-26 is considered moderate binge eating and above 27 is considered severe binge eating.[38,40]

Statistical Analyses

Linear mixed effects (LME) models compared ROC, BWL, and ROC+ with AC on changes in eating disorder symptoms at mid-treatment, post-treatment, and 6- and 12-month follow-up as well as differences in amount of change using two-way interactions between treatment and assessment terms. Planned covariates mirrored primary outcomes analyses [30] and included age, sex, loss of control eating, race/ethnicity, physical activity, BMI, dummy-coded contrasts identifying assigned pattern group and an additional corresponding value for eating disorder symptoms at baseline. Planned contrasts were assessed in separate LME models to enable a shift in contrast for comparison of the average effect of BWL and ROC+ with ROC and AC on Restraint, effects of ROC, BWL, and ROC+ compared to AC on Eating, Shape, and Weight Concern, and binge eating symptoms and the effects of ROC compared to BWL on Eating, Shape, and Weight concerns and binge eating symptoms. Additional contrasts compared eating disorder symptoms during and after treatment for ROC compared to BWL and AC.

We used multiple imputation software in Amelia [41] to accommodate missing assessments with rates of completed post-randomization assessments and inclusion in primary models ranged from 80% to 85% and did not differ across treatments (X^2=6.4, df=3, p=0.09). Model estimates were pooled using Rubin's rule and analyses were conducted in R [42] using the mice package.[43] Multiple imputation with 40 replicate combinations were formed using all predictors (age, sex, loss of control eating, race/ethnicity, physical activity, baseline BMI) in the evaluative model of each EDE-subscale. Complete data for subscales at mid-treatment, post-treatment, 6- and 12-month assessments ranged from 72% – 80%.

Results

Participant Characteristics.

271 adults were randomized to ROC ($n = 69$), BWL ($n = 69$), ROC+ ($n = 67$), and AC ($n = 66$). The average age of participants was 46.97 (SD = 11.8) years, 62% were non-Hispanic White (1 (<1%) American Indian, 16 (6%) Asian, 15 (6%) Black, 1 (<1%) Hawaiian-Pacific Islander, 54 (20%) Hispanic, 14 (5%) Multiple Race, 168 (62%) White, 2 (<1%) Not reported), and 81% were female and 18% male.[30]

Change in Eating Disorder Symptoms During Treatment

Figure 1 displays estimated means for Restraint, Eating, Shape, and Weight Concern from each treatment group across assessment occasions and Table 1 includes results of analyses. Ranges of Coefficient alpha for the baseline, mid-treatment, post-treatment, 6-month, and 12-month measurements of Restraint (0.60 – 0.68); Eating Concern (0.73 – 0.81); Shape Concern (0.82 – 0.83); Weight Concern (0.51 – 0.60), and the BES (0.90 – 0.91) were consistent across assessments. With coefficient H, a measure of scale accuracy in ordering respondents on a single construct, the observed vales (0.46-0.65) of >0.40 suggested medium and of >0.50 strong scaling[44] for all scales except Weight Concern which had H coefficients ranging from 0.31 – 0.45, indicating relatively weaker scalability.

Restraint.—Levels of Restraint increased significantly ($t(270) = 9.19$, $p < 0.01$) from baseline to mid-treatment across each of the four examined conditions with scores on average 0.87 points (95%CI = 0.69 – 1.06) higher at mid-treatment. Pooled estimates from adjusted LME models showed greater increases in Restraint symptoms for ROC+ and BWL during treatment when compared to AC (Hypothesis 1). Planned contrasts supported the hypothesis that on average, BWL/ROC+ had higher Restraint than AC ($b = 0.15$, 95%CI = 0.05 – 0.25) and ROC ($b = 0.12$, 95%CI = 0.02 – 0.22), effects that did not differ during or after treatment. We observed a lower level of Restraint in ROC compared to BWL ($b = -0.52$, 95%CI = -0.19 – -0.85) during and after treatment.

Eating Concern.—Scores decreased significantly from baseline to mid-treatment ($t = -10.29$, $p < 0.01$) with an average decrease of -0.67 (95%CI = -0.79 - -0.54). Pooled estimates from baseline adjusted LME models did not support differences in the decreased scores between ROC, BWL, ROC+ and AC at the mid-treatment or post-treatment assessments (Hypothesis 2). Across all groups, Eating Concern was lower at mid-treatment than post-treatment assessments ($b = -0.32$, 95%CI = -0.60 - -0.05). Planned contrasts did not support a significant difference in Eating Concern for ROC compared to BWL ($b = -0.01$, 95%CI = -0.19 – 0.18) during treatment (Hypothesis 3).

Shape Concern.—Scores decreased significantly from baseline to mid-treatment ($t(270) = -5.0$, $p < 0.01$) with an average decrease of -0.54 (95%CI = -0.75 - -0.33). We did not observe significant differences between ROC, BWL, ROC+ and AC levels of Shape Concern at mid- or post-treatment (Hypothesis 2). Across all conditions, Shape Concern did not change from mid- to post-treatment assessments ($b = 0.08$, 95%CI = -0.29 – 0.46). Planned contrasts did not support a significant difference in Shape Concern for ROC compared to BWL ($b = -0.23$, 95%CI = -0.53 – 0.07) during treatment (Hypothesis 3).

Weight Concern.—Scores decreased significantly ($t(270) = -2.23$, $p = 0.03$) from baseline to mid-treatment assessments with an average decrease of -0.23 (95%CI = -0.42 – -0.03). There were no significant differences in level of mid-treatment scores for ROC, BWL, ROC+ or AC (Hypothesis 2). Across all conditions, we observed no significant differences between mid-treatment and post-treatment ($b = -0.02$, 95%CI = -0.36 – 0.33) levels. Planned contrasts did not support a significant difference in Weight Concern for ROC compared to BWL ($b = 0.16$, 95%CI = -0.07 – 0.39) during treatment (Hypothesis 3).

Binge Eating Scale.—Scores decreased significantly ($t(270) = -14.59$, $p < 0.01$) from baseline to mid-treatment assessments with an average decrease of -6.64 (95%CI $= -7.53$ $- -5.74$). There were no significant differences in level of mid-treatment scores for ROC, BWL, ROC+ or AC (Hypothesis 2). Across all conditions, we observed no significant differences between mid-treatment and post-treatment ($b = 0.36$, 95%CI $= -0.67 - 1.38$) levels. Planned contrasts did not support a significant difference in BES for ROC compared to BWL ($b = 0.18$, 95%CI $= -1.49 - 1.84$) during treatment (Hypothesis 3).

Change in Eating Disorder Symptoms After Treatment

Restraint.—Across ROC+, BWL, ROC and AC arms, there was a significant increase in Restraint after treatment to the 12-month assessment ($b = 0.71$, 95%CI $= 0.35 - 1.07$). Both ROC+ and BWL had higher Restraint after treatment than AC. There were no significant differences in the amount of increase in Restraint from post-treatment to 12-month assessment for ROC+, BWL, or ROC compared to AC (p's > 0.26).

Eating Concern.—Eating Concern increased significantly after treatment at the 12-month assessment ($b = 0.79$, 95%CI $= 0.52 - 0.98$). There were no group differences in changes in Eating Concern from post-treatment to 12-month follow-up (p's > 0.13).

Shape Concern.—We observed significantly increased levels of Shape Concern after treatment at the 12-month assessment ($b = 0.78$, 95%CI $= 0.43 - 1.12$). There were no group differences in changes in Shape Concern from post-treatment to 12-month follow-up (p's > 0.23).

Weight Concern.—We observed a small increase in Weight Concern after treatment at the 12-month assessment ($b = 0.31$, 95%CI $= -0.01 - 0.63$) that was not statistically significant. Relative to AC, Weight-Concern in ROC+, BWL, and ROC were not significantly different after treatment (see Table 1). There were no group differences in changes in Weight Concern from post-treatment to 12-month follow-up (p's > 0.37).

Binge Eating Scale.—There were no significant differences in levels of total BES scores after treatment for ROC ($b = -1.04$, se $= 1.16$, $p = 0.37$), ROC+ ($b = -0.31$, se $= 1.25$, $p = 0.80$), or BWL ($b = -0.89$, se $= 1.21$, $p = 0.46$) compared to AC (see Figure 2). Overall levels of BES at 6- and 12-months did not differ from post-treatment levels and rates of change in BES after treatment were not significantly different between groups (p's > 0.60).

Relationship Between Eating Disorder Symptoms and Weight

We estimated whether levels of eating disorder symptoms and levels of BMI were associated during and after treatment. All models included baseline levels of BMI and corresponding levels of eating disorder symptom scales. This time-varying estimate suggested that higher BMI was associated with lower levels of Restraint (b $= -12$, se$=0.02$, p<0.01). Higher BMI was associated with both higher Eating Concern (b $=0.06$, se$=0.01$, p<0.01) and higher Shape Concern (b$=0.22$, se$= 0.02$, p<0.01). We did not observe a significant relationship between levels of BMI and levels of Weight Concern (b$=0.03$, se$=0.02$, p$=0.13$). The strength of these relationships did not differ during or after treatment (interaction of BMI by

assessments, p's >0.18). The relationship between BMI and Restraint symptoms during and after treatment (interaction of BMI by Treatment) was stronger for those in BWL relative to AC (b= −0.07, se =−0.03, p = 0.04). We did not observe significant differences in the relationship between BMI and Restraint symptoms across ROC or ROC+ treatments relative to AC (p's >0.09). We did not observe significant differences in the relationship between BMI and other eating disorder symptoms for any treatment relative to AC groups (p's >0.20).

Discussion

This study evaluated changes in eating disorder symptoms over the course of treatment and 12-month follow-up period in four arms of a randomized controlled weight loss trial for adults with OW/OB. All randomized participants demonstrated a general pattern of decreases in Eating, Shape, and Weight Concern and binge eating during treatment. Interestingly, the reductions in eating disorder symptoms were maintained through the 6-month follow-up. However, eating disorder symptoms measured by the EDE-Q returned to baseline levels at the 12-month follow-up while reductions in binge eating symptoms were maintained at 12-month follow-up. As predicted, there were significant differences between BWL and ROC+ and the other two arms on Restraint during treatment which dissipated during the follow-up. Overall, these findings suggest that concerns about weight loss treatment programs triggering eating disorder symptoms were not supported in the context of this four-arm weight loss trial.

This pattern of reduction in eating disorder symptoms and attitudes over the course of a weight loss program is consistent with a number of previously published studies.[45,46] The process of actively focusing on ones' health, learning healthy and functional strategies for managing weight, social support, or being successful in weight loss may contribute to the observed reduction in Eating, Shape, and Weight Concern and binge eating. In addition, reductions in binge and loss of control eating behaviors may also contribute to the decreases in Eating, Shape, and Weight Concern independent of weight loss. It is also possible that social support related to the group treatment environment and general program participation may have contributed to the observed reductions, as these decreases were seen across all four arms.

The reductions in eating disorder symptoms measured by the EDE-Q were maintained at 6-month follow-up but not at 12-month follow-up. It is possible increases in eating disorder symptoms on the EDE-Q between follow-ups could be due to challenges in maintaining treatment recommendations over time and could also be related to weight increases or stabilization seen after the active treatment period of the study. Interestingly, this pattern was not observed for binge eating as measured by the BES. It is possible trajectory differences observed between symptoms measured by the EDE-Q and the BES are due to the measurement of different constructs, as eating disorder symptoms in general are heterogeneous and none of the four EDE-Q scales measure binge eating directly. On the face, the EDE-Q measures upstream cognitive processes related to eating disorders while the BES measures more behavioral outcomes, which could explain this distinction. Lastly, a hallmark feature of binge eating is a sense of loss of control over eating. It is possible other

eating disorder-related cognitive processes can exist independently of loss of control, and loss of control eating does not hinge on these upstream processes. Future research should continue to investigate distinctions between loss of control eating and other eating disorder cognitions, and future interventions should target maintenance of improvements on eating disorder symptoms after weight loss treatment ends.

As hypothesized, increases in Restraint were observed in participants randomized to intervention arms that incorporated caloric restriction (i.e., ROC+ and BWL) during treatment as compared to AC and ROC. These increases in Restraint may reflect active efforts to control intake and reduce calories as prescribed by the treatment group. Increases in Restraint on the EDE-Q focus on limiting food, and the increase makes sense during interventions that recommend restricting food intake. It is important to note that the observed increase in Restraint in ROC+ and BWL dissipated after the active treatment period ended. Research suggests that restraint is a complex and heterogeneous construct. [43,44] While some items on the EDE-Q Restraint subscale measure pathological restraint (e.g., fasting, desire for an empty stomach), other items are consistent with recommendations from BWL programs and common among individuals seeking weight loss (e.g., intentionally reducing food intake for weight loss, following a calorie limit, desire for a flat stomach). Contradictory evidence exists in the literature as to whether restraint can be considered harmful or helpful in individuals with OW/OB[14,15,47,48] including the extent to which it is related to binge eating. One recent review concluded that a certain amount of restraint can be a beneficial for weight loss in individuals with OW/OB and was not found to be related to harmful eating pathology when practiced in the context of a well-validated weight management program.[47] Additionally, measures of dietary restraint across studies are inconsistent and assess heterogeneous constructs, which may explain contradictory findings about the relationship between restraint and eating disorder symptoms.[48,49]

Like exercise, restraint exists on a spectrum from healthy to problematic. Restraint is likely to become problematic when it manifests in rigid food rules. Further psychometric testing and standardization of measures of eating behaviors including restraint across studies would be useful to better understand its heterogeneity and relation to other health outcomes, and to understand if there may be a certain cut point as to when restraint becomes psychopathological. Research suggests cognitive rigidity and restraint intention may be the drivers of when restraint results in problematic outcomes and eating disorder symptoms. [14,50,51] Interventions that modify unrealistic intentions and focus on helping individuals develop flexible restraint (e.g., following dietary guidelines rather than rules) may be successful in incorporating helpful aspects of restraint for weight loss without provoking eating disorder symptoms.

ROC did not impact Restraint in the same manner as ROC+ and BWL, which is most likely due to the focus on managing eating behavior when exposed to food cues. ROC does not promote caloric restriction, instead it teaches skills to reduce overall eating without counting calories. Not surprisingly, the AC group was also not associated with an increase in Restraint, most likely due to the lack of instructions to reduce intake or self-monitor eating. In our published trial, the ROC group demonstrated both weight loss and weight loss

maintenance without requiring caloric restriction [30] and ROC was the only group that did not experience the weight regain that was seen in the BWL participants[30]. Thus, the ROC program may be a promising weight loss treatment that does not require dietary restraint and minimizes the risk of exacerbating pre-existing eating disorder symptoms. While the ROC+ group did recommend calorie counting like BWL, it is possible the ROC+ group could still be helpful for some individuals. Maintaining emphasis on nutrition information and energy density but decreasing emphasis on calorie counting could be beneficial in helping participants to increase nutrient-dense foods while modeling flexible restraint. Additionally, for participants who have difficulty sensing their hunger/fullness, an external guide of calories may help the participant manage their eating. Further, it would be important to make distinctions in treatment between flexible and rigid restraint, and caution participants against setting rigid food rules.

These results also suggest that changes in eating disorder symptoms are associated with changes in BMI and that this interrelationship does not depend on the types of treatment being delivered. The one exception would be Restraint symptoms which do seem to be more strongly related to changes in BMI among those in BWL relative to the AC condition. While these results suggest a significant association between changing levels of eating disorder symptoms and changing BMI both during and after treatment, we do not suggest a causal direction for these associations. Studies suggest that weight status is one of the most consistent predictors of eating disorder symptoms with increased symptoms associated with higher body weight.[52] It is possible that future research could focus on early interventions in eating disorder symptoms among those of higher body weight.

Study strengths include a diverse sample of treatment-seeking adults and the evaluation of the impacts of a novel intervention, ROC, on eating disorder symptoms over multiple timepoints. Study limitations include a predominantly female and treatment-seeking sample. Additionally, the EDE-Q and BES include a broad range of symptoms; however, they do not comprehensively measure all aspects of eating disorder symptoms.

In summary, our data showed that Eating, Weight, and Shape Concerns as well as binge eating decreased in all four arms of the PACIFIC study: ROC, ROC+, BWL and AC. As expected, the two arms that included dietary restriction did result in increased Restraint, which dissipated after treatment. Because it had comparable results to the other treatment conditions without increases in dietary restraint, ROC could be considered the treatment of choice for weight loss among individuals who are at risk for eating disorder symptoms. Continuing to monitor how weight loss interventions impact eating behaviors and eating disorder symptoms, and how these changes may outlast intervention time periods, will be important to further understand the long-term impact of weight loss treatments on eating disorder symptoms as well as disordered eating.

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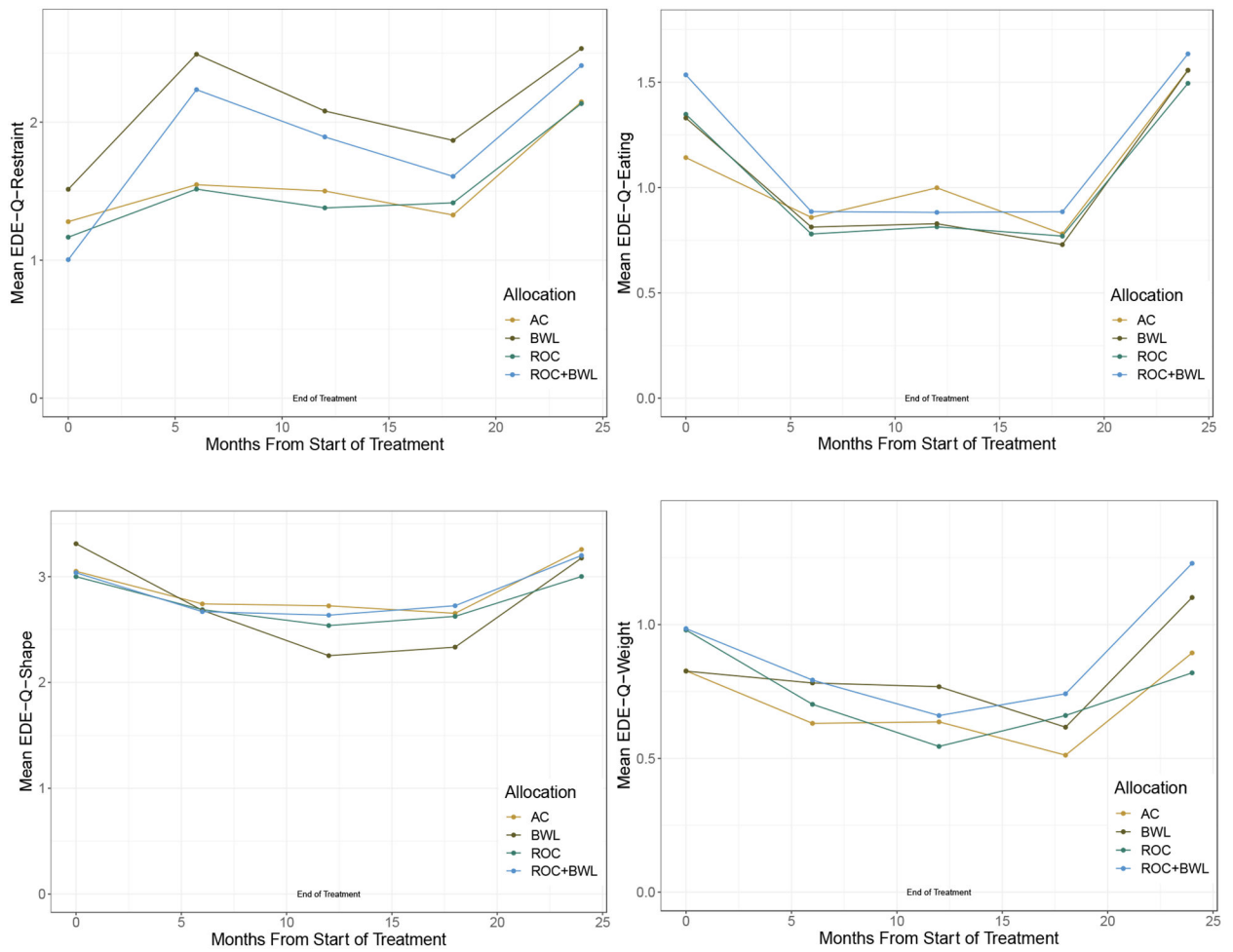
Figure 1.
Eating Disorder Examination – Questionnaire (EDE-Q) subscales during and after weight
loss treatment for all four arms: regulation of cues (ROC), behavioral weight loss (BWL), a
combination of ROC+BWL (ROC+) and an active comparator (AC).

Figure 2.
Binge eating symptoms measured by Binge Eating Scale (BES) during and after weight loss treatment for all four arms: regulation of cues (ROC), behavioral weight loss (BWL), a combination of ROC+BWL (ROC+) and an active comparator (AC).
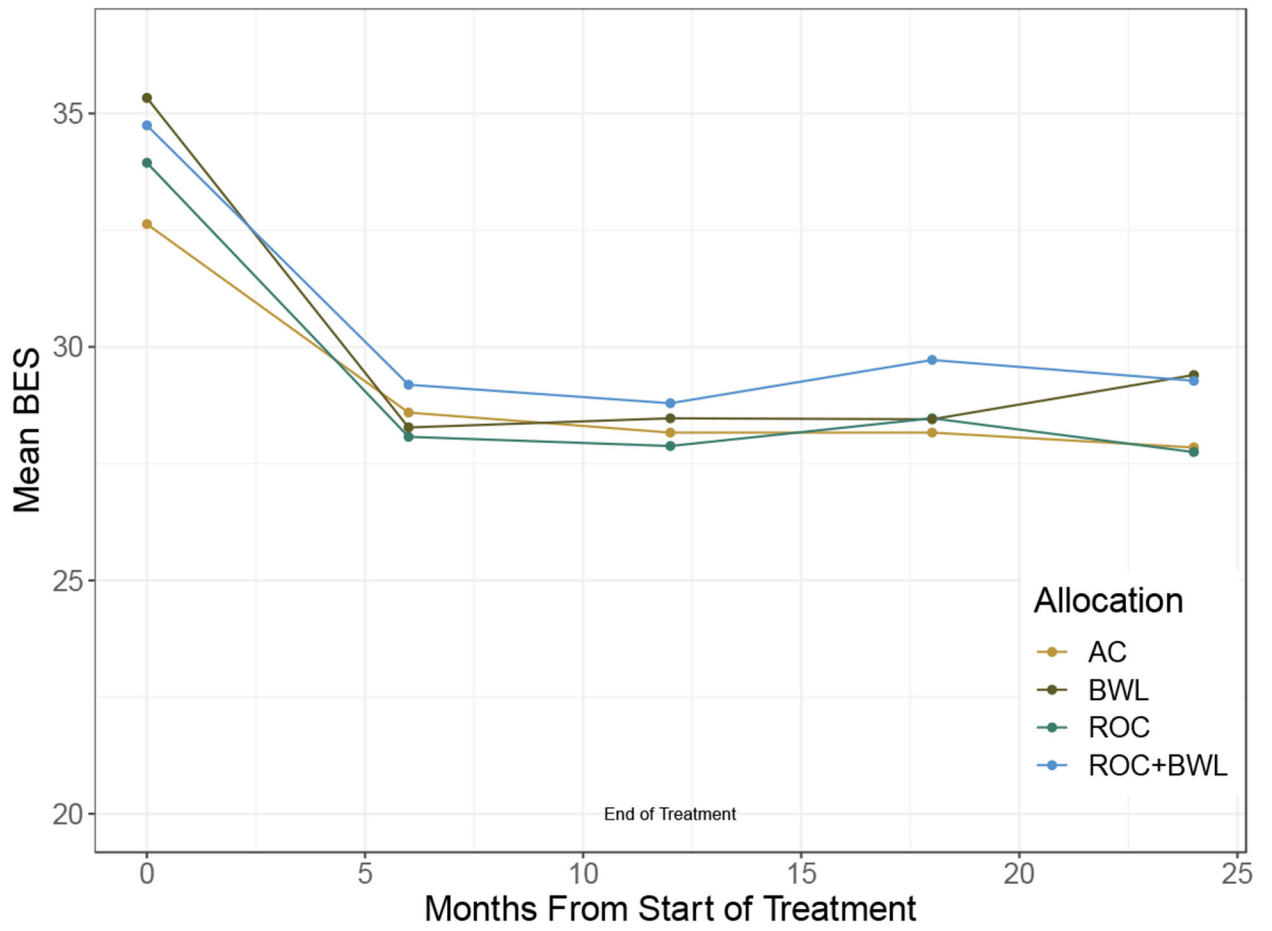
Table 1.

Linear mixed effect models examining changes in Eating Disorder Examination – Questionnaire (EDE-Q) subscales during and after weight loss treatment.

term	Restraint			Eating Concern			Shape Concern			Weight Concern		
	B	se	p	B	se	p	B	se	p	B	se	p
Assessment												
Mid-Treatment	0.07	0.18	0.70	−0.32	0.14	0.02	0.08	0.19	0.67	−0.02	0.18	0.92
Post-Treatment	--	--	--	--	--	--	--	--	--	--	--	--
6m Follow-up	−0.18	0.19	0.33	−0.20	0.12	0.10	0.07	0.18	0.70	−0.14	0.17	0.41
12m Follow-up	0.71	0.18	<0.001	0.75	0.12	<0.001	0.78	0.17	0.00	0.31	0.16	0.055
Weight Loss Treatments Compared to Active Comparator (AC)												
AC	--	--	--	--	--	--	--	--	--	--	--	--
ROC	−0.03	0.24	0.91	−0.23	0.15	0.14	−0.16	0.23	0.49	−0.18	0.19	0.33
BWL	0.54	0.23	0.02	−0.26	0.15	0.08	−0.56	0.22	0.01	0.04	0.19	0.81
ROC+	0.48	0.24	0.048	−0.26	0.15	0.08	−0.10	0.22	0.67	−0.07	0.20	0.75
Assessment by Weight Loss Treatment Interactions												
ROC												
Mid-Treatment	0.08	0.27	0.78	0.15	0.19	0.45	0.17	0.26	0.53	0.26	0.25	0.28
Post-Treatment	--	--	--	--	--	--	--	--	--	--	--	--
6m Follow-up	0.09	0.27	0.75	0.14	0.17	0.41	0.08	0.26	0.76	0.21	0.23	0.36
12m Follow-up	0.14	0.26	0.59	0.14	0.17	0.40	−0.11	0.25	0.67	0.06	0.23	0.80
BWL												
Mid-Treatment	0.40	0.26	0.13	0.14	0.19	0.46	0.40	0.26	0.12	0.11	0.24	0.66
Post-Treatment	--	--	--	--	--	--	--	--	--	--	--	--
6m Follow-up	−0.07	0.26	0.79	0.16	0.18	0.37	0.08	0.25	0.75	0.01	0.23	0.97
12m Follow-up	−0.19	0.25	0.44	0.21	0.18	0.24	0.32	0.24	0.19	0.14	0.23	0.54
ROC+												
Mid-Treatment	0.35	0.27	0.20	0.21	0.19	0.27	0.09	0.28	0.74	0.24	0.26	0.36
Post-Treatment	--	--	--	--	--	--	--	--	--	--	--	--
6m Follow-up	−0.14	0.28	0.62	0.24	0.17	0.16	0.17	0.24	0.48	0.22	0.26	0.40
12m Follow-up	−0.01	0.26	0.98	0.27	0.16	0.10	0.09	0.25	0.73	0.38	0.25	0.12

Note: All models included baseline values for respective EDE-Q scales, Body Mass Index, age, sex, race/ethnicity, loss of control eating, physical activity, and drop-out group assigned during original analysis of primary outcomes.[30] All models include pooled estimates of multiple imputations. B = beta estimate from LME model; se = standard error; p = p-value. Treatments include: regulation of cues (ROC), behavioral weight loss (BWL), a combination of ROC+BWL (ROC+) and an active comparator (AC).