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Relationship of Emotional Eating and Mood Changes Through Self-Regulation Within Three Behavioral Treatments for Obesity

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Abstract

An enhanced understanding of the dynamics of psychosocial change processes within behavioral weight loss treatments is required to improve their generally poor results. Based on social cognitive theory, self-regulation of eating has the possibility of affecting interrelations between psychosocial correlates of inappropriate eating behaviors such as emotional eating and negative mood. Within behavioral interventions, physical activity, treatment foci, and the length of treatment might moderate those relationships. The aim of this research was to contrast intervention effects based on treatment type, and evaluate interrelations of changes in theory-based psychosocial variables. Adult females with obesity (overall $M_{age} = 48.6$ years; overall $M_{BMI} = 35.3$ kg/m^2) were block randomized into groups of 28 weeks of phone-supported manual-based education (Group 1, $n = 52$), 58 weeks of cognitive-behavioral group treatment (Group 2, $n = 52$), and 99 weeks of cognitive-behavioral group treatment followed by phone-based reviews of intervention materials (Group 3, $n = 48$). Significant improvements in measures of emotional eating, negative mood, self-regulation for controlling eating, physical activity, and body composition were found in each group over 3, 6, 12, and 24 months, with generally larger effect sizes detected in Groups 2 and 3. Reciprocal, mutually reinforcing, relationships were found between changes in emotional eating and mood, which were significantly mediated by self-regulation changes. Physical

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activity level significantly moderated mood changes, treatment foci on emotional eating significantly moderated changes in emotional eating, and treatment length significantly moderated long-term changes in emotional eating, but not mood. Findings support a treatment duration of at least one year that emphasizes physical activity and self-regulatory skills usage, and interrelations between changes in emotional eating, self-regulation, mood, and physical activity.

Keywords
Emotional eating, mood, obesity, physical activity, self-regulation, treatment length

Introduction

The treatment of obesity through behavioral methods has rarely been successful beyond the initial several months (Jeffery et al., 2000; Lemmens, Oenema, Klepp, Henriksen, & Brug, 2008; Mann et al., 2007). It has been posited that much of this problem is due to a poor understanding of psychosocial correlates of excessive eating behaviors such as mood and emotional eating (Teixeira et al., 2010), which are primary drivers of weight gain (Koenders & van Strien, 2011). It is likely that changes in psychosocial factors interact with one another over time in a dynamic fashion and, as such, should to be better accounted for within interventions.

Presently, behavioral (nonpharmacological and nonsurgical) treatments vary widely. Aside from commercial diets that often promise unrealistic results in brief time frames (Federal Trade Commission, 2018), more scientifically based treatments vary in their length and foci (Degenio, Mancuso, Gerber, & Dvorak, 2009; Jones & Wadden, 2006). Even though evidence supports the association of longer treatments with better effects (Jeffery et al., 2000; Simpson, Shaw, & McNamara, 2011), brief treatments of just several weeks or months are common. Although cognitive-behavioral treatments with their bases in social cognitive theory and control over the environment and psychological processes (Bandura, 1986, 2005) have demonstrated the most favorable long-term effects (Lang & Froelicher, 2006), atheoretical interventions that simply educate individuals on nutritional information are common. Although considered "state-of-the-science" (Wing & Hill, 2001), cognitive-behavioral treatment outcomes have also generally been inadequate (Greaves et al., 2011; Loveman et al., 2011; Teixeira et al., 2015), with regain of weight consistently beginning between six and nine months after treatment start (Jeffery et al., 2000; Mann et al., 2007; MacLean et al., 2015). Thus, the relevance of the plethora of treatment studies of only several months duration has been questioned (MacLean et al., 2015).

Although physical activity has been a strong predictor of sustained weight loss (Jones & Wadden, 2006), behavioral treatments are often reticent to mandate it in fear that it will compromise their primary focus on eating changes (Cooper, Fairburn, & Hawker, 2003). Conversely, though, a few interventions have successfully incorporated cognitive-behavioral exercise adherence methods (Annesi, 2012). Research is not yet at the stage of determining causality for ultimate effects on weight change. However, it has been proposed that longer treatments keep participants more accountable, cognitive-behavioral treatments enable participants to better utilize self-regulatory skills to overcome common barriers (e.g., social pressure to overeat, cravings, slow progress), and facilitating physical activity promotes weight loss success through its effects on salient psychosocial factors (Baker & Brownell, 2000).

Although emotional eating might be induced by negative mood, emotional eating may also lead to negative mood. When an individual experiences emotional or binge eating, reflecting on those behaviors might induce guilt and low mood because of an awareness of the destructive nature of lacking adequate control (Andrews, Lowe, & Clair, 2011; Elmore & de Castro, 1990). It is possible that there is a bidirectional, mutually reinforcing (i.e., reciprocal), relationship between changes in mood and emotional eating. This scenario could be expected to be most prominent in females, largely because they experience higher emotional eating levels (Goldbacher et al., 2012; Penéau, Ménard, Méjean, Bellisle, & Hercberg, 2013). It was also proposed that "emerging adults" (i.e., individuals of ages 18–29 years; Arnett, Žukauskienė, & Sugimura, 2014) are affected by psychosocial processes differently within weight loss efforts from adults and, thus, they require separate evaluation (Johnson & Annesi, 2018).

Self-regulation skills (e.g., relapse prevention, cognitive restructuring) have strong implications for controlling eating and promoting success with weight loss (Baker & Brownell, 2000; Bandura, 2005). Within that relationship, self-regulation, which is considered to be a limited resource (Hagger, Wood, Stiff, & Chatzisarantis, 2010), might play a prominent role in an association between changes in mood and emotional eating (Stoeckel et al., 2017). For example, treatment-associated changes in self-regulation could be both affected by, and impact, emotional eating and mood. However, this is an understudied area. If treatment-associated changes in the use of self-regulatory skills for controlling eating are shown to significantly mediate the mood-emotional eating change relationship, their self-regulation components might be accordingly tailored and emphasized in future interventions. For example, if self-regulatory skills can help control emotion-based eating, emanating from low mood, a new role for their use might emerge that would enhance probabilities for success with long-term weight loss. The prediction of changes in emotional eating by mood changes (and vice versa) might best be assessed longitudinally through a lagged statistical approach where earlier changes are assessed for their prediction of

changes over longer periods (Singer & Willet, 2003). In that manner, implications for both short- and long-term changes could be adequately evaluated, with the mediating properties of self-regulation also held to account.

Thus, the present research on women with obesity incorporated three behavioral weight loss treatments that differed in their durations, theoretical orientations (educational vs. self-regulatory emphases), and foci on physical activity. To address potential confounds suggested above, only women of 30 years and older were recruited. Changes in emotional eating, mood, and self-regulation at various intervals over a two-year period were first contrasted, then the prediction of changes in emotional eating by negative mood changes (and vice versa) were evaluated while also accounting for treatment-associated changes in eating-related self-regulatory skills usage. As suggested to enhance generalizability of findings and expedite their applications (Baranowski, Lin, Wetter, Resnicow, & Hearn, 1997; Green, Sim, & Breiner, 2013), existing community-based health promotion sites and their staffs were utilized within the present field research.

Primary hypotheses were (a) there would be significant improvements in emotional eating, mood, self-regulation, physical activity, and body composition for each group, with a cognitive-behavioral treatment orientation associated with larger effects, (b) considering aggregated data, there would be reciprocal relationships between changes in emotional eating and negative mood over 6, 12, and 24 months, and (c) also considering aggregated data, changes in self-regulation for controlling eating would significantly mediate those relationships. Secondary hypotheses were (a) level of physical activity would significantly moderate the prediction of mood change by emotional eating, (b) an increased treatment focus on emotional eating would significantly moderate the prediction of emotional eating change by mood change, and (c) the length of treatment would significantly moderate effects on both emotional eating and mood into the second year of analyses.

Method

Participants

Women with obesity (i.e., body mass index (BMI) $\geq$ 30 kg/m^2) were recruited through print and electronic media near community health promotion centers in the eastern United States. To avoid cross-contamination through participants interacting with one another about treatment processes, treatment conditions were first randomly assigned to facilities, then participants were randomly assigned to those facilities in rotating order (i.e., block randomization; Suresh, 2011). Based on the power analysis described in the data analysis subsection below, and expected attrition prior to treatment initiation, 57 women of a minimum age of 30 years were recruited per treatment condition. Inclusion criteria included: self-reporting less than the recommended 150 minutes/week of

moderate physical activity per week (U.S. Department of Health and Human Services, 2008), a goal of weight loss, not presently participating in another weight-management treatment, free from psychotropic medication use, and no present/soon-planned pregnancy. Institutional review board (IRB) approval was obtained, and IRB-approved consent forms were required to be signed by participants prior to initiating treatment. Ethical requirements of the Helsinki Declaration were observed throughout.

After attrition associated with minor adverse medical conditions (e.g., injuries/colds), transportation problems, not returning study staff communications, and failing to appear at the initial scheduled session, Group 1 ($n = 52$), Group 2 ($n = 52$), and Group 3 ($n = 48$) did not significantly differ on age (overall $M_{age} = 48.6$ years, $SD = 7.0$), body composition (assessed as BMI overall $M_{BMI} = 35.3$ kg/m^2, $SD = 3.2$), ethnicity/racial makeup (overall 80% White, 15% Black, 5% other), educational level (overall 68% bachelor's degree or higher), or reported yearly family income (overall median ~US$48,000/year).

Measures

The psychosocial surveys selected had the internal consistencies of their items assessed through Cronbach's α. Test–retest reliabilities were assessed over two to three weeks. The adequacy of the physical activity measure was assessed through assessments of concurrent and predictive validity.

Emotional eating was measured using the Emotional Eating Scale (Arnow, Kenardy, & Agras, 1995). That scale assesses the extent that feelings related to anxiety (e.g., "nervous"), depression (e.g., "blue"), and anger (e.g., "irritated") lead the respondent to an urge to eat. However, subsequent factor analyses suggested that somatic arousal (e.g., "jittery") might also be measured within the scale (Goldbacher et al., 2012). Responses range from 0 (*No desire to eat*) to 4 (*An overwhelming urge to eat*). After summing the 15 items, the possible score range was 0 to 60, with a higher score indicating a greater degree of emotional eating. Reported internal consistencies averaged $\alpha = .76$, and test–retest reliability was .79 (Arnow et al., 1995). Because binge eating disorder scores were significantly associated with Emotional Eating Scale scores (Arnow et al., 1995; Eldredge & Agras, 1996), concurrent validity was also indicated. For the present sample, the internal consistency averaged $\alpha = .75$.

Negative mood was measured using the Profile of Mood States—Brief (McNair & Heuchert, 2009). Its 30 items are related to a respondent's feelings of depression/dejection (e.g., "gloomy"), tension/anxiety (e.g., "anxious"), fatigue/inertia (e.g., "sluggish"), anger/hostility (e.g., "furious"), confusion/bewilderment (e.g., "bewildered"), and vigor/activity (e.g., "active"). Responses range from 0 (*Not at all*) to 4 (*Extremely*). After summing item scores, with scores on the five items related to vigor/activity items reversed, the possible score range was −20 to 100. A lower score indicated less negative mood. Reported internal

consistencies averaged $\alpha = .91$, and test–retest reliabilities averaged .69 (McNair & Heuchert, 2009). Concurrent validity was also indicated through strong correlations between Profile of Mood States scores and scores on accepted tests of depression, anxiety, and personality (McNair & Heuchert, 2009). For the present sample, internal consistencies averaged $\alpha = .85$.

Self-regulation for controlling eating was measured by adapting a previous scale (Saelens et al., 2000) for use in the present research context (Annesi & Marti, 2011). Its 10 items assess degree of use of specific self-regulation skills applied by the respondent to control eating (e.g., "I set eating-related goals"). Responses range from 1 (*Never*) to 5 (*Often*). The possible score range was 10 to 50, with a higher score indicating more self-regulatory skill use for controlling eating. Reported internal consistency was $\alpha = .81$, and test–retest reliability was .74 (Annesi & Marti, 2011). Change in scale scores were negatively associated with change in weight over six months, which indicated predictive validity (Annesi & Marti, 2011). For the present sample, internal consistencies averaged $\alpha = .79$.

Physical activity was measured by the Leisure-Time Physical Activity Questionnaire (Godin, 2011). It measures weekly physical activity through estimates of metabolic equivalents of task (METs; a unit of energy expenditure where 1 MET approximates 3.5 mL of O_2/kg/min; Jetté, Sidney, & Blumchen, 1990). Entry of the respondent's number of physical activity sessions/week of a 15-minute duration or greater, ranging from light (e.g., easy-paced walking, scored 3 METs) to strenuous (e.g., running, scored 9 METs), is required. Those entries are summed to give a final score of METs/week (e.g., three sessions of easy-paced walking (9 METs) and one session of running (9 METs) would total 18 METs). Reported test–retest reliability was .74 (Godin & Shephard, 1985). Predictive and concurrent validity of the Leisure-Time Physical Activity Questionnaire was indicated through significant correspondences (p values $< .001$) between its scores, and scores on treadmill tests assessing maximal oxygen uptake, and accelerometer scores (Jacobs, Ainsworth, Hartman, & Leon, 1993; Miller, Freedson, & Kline, 1994).

Body composition was measured using BMI, which is calculated as kg/m^2. Weight was measured using a recently calibrated digital scale. Height was measured using a stadiometer. The mean of two consecutive measurements was recorded.

Procedure

Wellness instructors from community health promotion centers administering the various weight management treatments were trained in only one protocol and masked from the others. Each wellness instructor had at least one national certification related to health promotion (e.g., American College of Sports Medicine, American Council on Exercise, YMCA). Each participant initially

received a phone communication from study staff who overviewed her assigned treatment condition.

In Group 1, participants reviewed 12 topics over 28 weeks derived from weight management manuals used in previous research and applications (Brownell, 2004; Kaiser Permanente Health Education Services, 2008). Every two weeks, a wellness leader lead a conference phone call of 15–20 minutes (with three to four participants on the call) that encouraged questions, comments, and practical aspects of the assigned content. Examples of topics included: United States government's dietary guidelines, controlling food and calorie intake, benefits and types of physical activities, and benefits and disadvantages of food types within a challenging food environment. The primary focus of the treatment for Group 1 was education related to the weight loss process—as described by Abraham and Michie (2008) as falling within the "informational-motivation-behavioral skills" treatment model.

In Group 2, participants were administered six sessions (~45 minutes/session) of one-on-one exercise support over 28 weeks that emphasized behavioral goal setting and contracting, setting graded tasks, self-monitoring of behaviors, performance feedback, barrier identification, identification of prompts/cues, self-talk/cognitive restructuring, relapse prevention, stress management, and time management—as described by Abraham and Michie (2008) as falling within the "social-cognitive theory," "operant conditioning," and "control" treatment models. After the initial eight weeks of structured, cognitive-behaviorally based exercise support (Annesi, 2012), food/calorie tracking was added. Beginning at Week 10, 24 structured nutrition change sessions (~60 minutes/session) were administered in groups of 8–15 participants every two weeks. Consistent with research suggesting an ability to generalize self-regulatory skills developed in a physical activity context, to other health behavior contexts (Oaten & Cheng, 2006), the content of the nutrition-change sessions focused on adapting the physical activity-centered self-regulatory skills for eating behavior changes. Research-based suggestions on the use of moderate physical activity to improve mood (Landers & Arent, 2007) and controlling emotion-based eating (Mata et al., 2009) were addressed in approximately half of the sessions. The primary focus of the full 58-week protocol of Group 2 was addressing barriers to physical activity and nutrition change.

In Group 3, participants were administered the same treatment methods as Group 2, with the addition of five conference phone calls (with the instructor and three to four participants on the call), each spaced by eight weeks. These 15- to 20-minute calls that reinforced learned self-regulation skills were held after the group nutrition change sessions concluded at Week 58. This lengthened Group 3 treatment protocol to 98 weeks.

Measurements were completed by study staff in a private area at baseline, and Months 3, 6, 12, and 24. Structured fidelity checks were completed by study staff during approximately 15% of treatment sessions. The few minor

compromises to the protocols were easily rectified through conversations between study staff and the wellness instructors administering the treatments.

Data analysis

After confirming that missing data within the intention-to-treat analysis were missing-at-random based on suggested criteria (White, Horton, Carpenter, & Pocock, 2011), the expectation–maximization algorithm (Schafer & Graham, 2002) was incorporated to impute data for the 10% of missing cases. Based on primary planned regression analyses incorporating two predictors, an overall sample size of 129 was required to detect a small/moderate effect of $f^2 = .10$ at the conservative power level of .90 ($\alpha = .05$) (Cohen, Cohen, West, & Aiken, 2003). As suggested under the present conditions (Glymour, Weuve, Berkman, Kawachi, & Robins, 2005), gain scores were unadjusted for baseline value. Variance inflation factors ranged from 1.05 to 1.11, which indicated acceptable multicollinearity in the data. Analyses were conducted using SPSS Statistics Version 22 (IBM, Armonk, NY) incorporating the PROCESS Version 2 macroinstruction software Models 4 and 5 (Hayes, 2013).

General Linear Model mixed-model repeated-measures analyses of variance first assessed whether changes in study measures from baseline to Months 3, 6, 12, and 24 differed between the three groups. Follow-up independent t tests assessed between-group differences within the temporal intervals. Dependent t tests assessed within-group changes. For those analyses, statistical significance was set at $\alpha < .05$ (two-tailed), with small, moderate, and large effect sizes indicated by partial eta-square ($\eta_p^2 = SS_{effect}/[SS_{effect} + SS_{error}]$) and Cohen's d ($d = M_{Time2} - M_{baseline}/SD_{baseline}$) values of .06, .14, .20, and .20, .50, and .80, respectively.

Next, mediation models, with lagged variables to infer directionality of the predictor and mediator on change in the outcome variable from baseline to Months 6, 12, and 24 (Cromwell, Hanna, Labys, & Terraza, 1994), were fit using aggregated data. For example, change in emotional eating over the initial three months predicted mood change over six months. A bias-corrected and accelerated bootstrapping method with 20,000 resamples of the data was used (Hayes, 2013). Beta values for Path c (predictor→outcome), and Path a (predictor→mediators), Path b (mediators→outcome), and Path c' (predictor→outcome, controlling for the mediator), were reported. Significance of mediation is detected when a score of zero is not found between the lower and upper limits of a 95% confidence interval (95% CI). Changes in mood predicted by emotional eating changes were first assessed, where the reverse was next assessed. Change in self-regulation for controlling eating was the consistent mediator in each equation. When a significant corresponding relationship is found in both directions (i.e., change in emotional eating significantly predicting mood change, *and* change in mood significantly predicting emotional eating

change), a reciprocal (mutually reinforcing) relationship may be inferred (Palmeira et al., 2009). Based on theory (Bandura, 1986, 2005) and a consistent directionality of findings in previous related research (Annesi, 2012; Teixeira et al., 2015), statistical significance was set at $p < .05$ (one-tailed) for those regression analyses.

Finally, the abovementioned models were fit to account for moderation of the relationship between the predictor and outcome variables on (a) mood change by physical activity level (at Months 3, 6, or 12, based on the period of assessed change in the predictor and mediator), (b) emotional eating change by treatment curriculum emphases on emotional eating (Groups 2 and 3 code = 1 [higher emphasis], Group 1 code = 0 [lower emphasis]), and (c) change in both mood and emotional eating over 24 months by the length of treatment (treatment corresponding to Groups 1, 2, and 3 was progressively lengthier and coded accordingly). Significance of moderation is detected when a score of zero is not found within a 95% CI of the predictor × moderator interaction term (Hayes, 2015). Some possible intervals were omitted from analyses because of the limited statistical power (associated with the present number of participants) and associated concerns for Type I errors.

Results

There was no significant group difference in baseline scores of emotional eating, negative mood, or self-regulation for controlling eating, F values (2, 151) = 1.66, 1.80, and 1.27, respectively, p values > .15.

Score changes, by group

Scores at each assessed time, change scores, and associated effect sizes are given in Table 1. For emotional eating, the overall time × group effect was not significant, $F(2, 149) = 1.72$, $p = .092$, $\eta_p^2 = .023$. However, follow-up tests indicated that Group 1 had significantly more reduction in emotional eating from baseline–Month 6 than the other two groups. For negative mood, there was a significant overall time × group effect, $F(2, 149) = 4.80$, $p = .010$, $\eta_p^2 = .060$. Follow-up tests indicated that reductions in negative mood were significantly greater in Groups 2 and 3 than in Group 1 for each assessed temporal interval. For self-regulation for controlling eating, the overall time × group effect was significant, $F(2, 149) = 3.09$, $p = .048$, $\eta_p^2 = .040$. Follow-up t tests indicated that improvements in self-regulation in Groups 2 and 3 were significantly greater than in Group 1 for each assessed temporal interval except baseline–Month 24, where only Group 3 maintained that significant difference. Within-group t tests indicated significant improvements on all psychosocial measures for each group, over each assessed temporal interval. Effect sizes for those changes were lower in Group 1 than in Groups 2 and 3. Within Groups 2 and 3, score improvements,

Table 1. Changes in study variables from baseline.

	Baseline		Month 3		Δ Baseline–Month 3			Month 6		Δ Baseline–Month 6			Month 12		Δ Baseline–Month 12			Month 24		ΔBaseline–Month 24		
	M	*SD*	*M*	*SD*	*M*	*SD*	*d*	*M*	*SD*	*M*	*SD*	*d*	*M*	*SD*	*M*	*SD*	*d*	*M*	*SD*	*M*	*SD*	*d*
Emotional eating																						
Group 1	25.50	11.58	22.38	9.39	−3.11	8.72*	.27	19.46	9.83	−6.04	8.50**	.52	19.08	9.78	−6.42	10.89**	.55	18.92	9.20	−6.58	10.63**	.57
Group 2	28.08	10.93	21.64	11.18	−6.43	9.19**	.59	17.92	9.32	−10.15	9.91**	.93	19.25	10.98	−8.83	10.50**	.81	20.30	10.80	−7.78	11.00**	.71
Group 3	24.00	11.59	17.85	9.84	−6.15	9.56**	.53	16.34	10.48	−7.66	8.27**	.66	18.56	11.31	−5.44	10.07**	.47	18.25	11.43	−5.75	11.03**	.50
Negative mood																						
Group 1	21.02	11.30	12.21	8.05	−8.81	10.06^{**,a}	.78	13.35	11.57	−7.67	10.35^{**,a}	.68	12.67	11.83	−8.35	11.15^{**,a}	.74	13.21	11.57	−7.81	11.19^{**,a}	.69
Group 2	26.23	15.48	9.11	15.33	−17.23	15.92^{**,b}	1.11	4.36	11.86	−21.88	17.13^{**,b}	1.41	8.10	12.15	−18.13	17.15^{**,b}	1.17	9.52	14.17	−16.71	16.94^{**,b}	1.08
Group 3	24.46	15.66	6.26	11.34	−18.17	15.49^{**,b}	1.16	3.50	11.19	−20.16	14.72^{**,b}	1.34	6.90	13.27	−17.56	17.47^{**,b}	1.12	7.60	15.06	−16.85	15.49^{**,b}	1.08
Self-regulation																						
Group 1	21.96	5.89	26.81	5.67	4.85	5.75^{**,a}	.82	26.81	5.67	4.67	5.33^{**,a}	.79	26.27	5.20	4.31	5.55^{**,a}	.73	25.69	5.19	3.73	5.93^{**,a}	.63
Group 2	23.63	5.56	32.39	4.71	8.76	7.14^{**,b}	1.58	32.71	4.00	9.08	6.08^{**,b}	1.63	32.04	4.25	8.40	6.70^{**,b}	1.51	29.79	5.81	6.15	7.72^{**,a}	1.11
Group 3	22.33	5.34	31.83	4.50	9.50	6.96^{**,b}	1.78	32.41	4.57	10.07	7.34^{**,b}	1.89	30.50	6.25	8.17	7.97^{**,b}	1.53	30.31	5.98	7.98	8.27^{**,b}	1.49
Physical activity (METs/week)																						
Group 1	8.75	7.22	21.58	13.80	12.83	11.68^{**,a}	1.78	22.75	12.78	14.00	10.48^{**,a}	1.94	22.96	12.71	14.21	11.31^{**,a}	1.97	22.31	12.41	13.56	10.73^{**,a}	1.88
Group 2	8.27	7.41	29.12	13.78	20.87	13.48^{**,b}	2.81	33.24	15.77	24.97	15.49^{**,b}	3.37	32.46	15.46	24.19	15.23^{**,b}	3.26	23.36	15.50	15.09	14.29^{**,a}	2.04
Group 3	5.92	6.48	32.63	20.12	26.71	20.75^{**,b}	4.12	37.48	20.59	31.56	21.23^{**,b}	4.87	30.88	16.02	24.96	16.88^{**,b}	3.85	30.97	15.93	25.05	16.68^{**,b}	3.87
Body composition (BMI; kg/m^2)																						
Group 1	36.11	3.13	35.78	3.23	−.33	.95^{*,a}	.11	35.33	3.35	−.78	1.16^{**,a}	.25	35.51	3.71	−.60	1.84^{†,a}	.19	35.76	3.77	−.36	1.90^{a}	.12
Group 2	34.65	3.28	33.53	3.52	−1.12	.93^{**,b}	.34	32.53	3.62	−2.13	1.34^{**,b}	.67	32.58	3.75	−2.08	1.63^{**,b}	.63	32.77	4.26	−1.88	3.16^{**,b}	.57
Group 3	35.01	3.18	33.89	3.06	−1.13	1.08^{**,b}	.36	32.83	3.28	−2.18	1.94^{**,b}	.69	33.07	3.59	−1.94	2.40^{**,b}	.61	33.09	3.26	−1.92	2.41^{**,b}	.60

Note: A different letter superscript between groups within the change terms on same variable indicates their significant mean difference ($p \leq .05$, two-tailed), based on follow-up *t* tests. Group 1, $n = 52$. Group 2, $n = 52$. Group 3, $n = 48$. d = Cohen's d ($M_{\text{Time 2}} - M_{\text{baseline}}/SD_{\text{baseline}}$). Δ = change in score between the indicated times. BMI: body mass index; METs: metabolic equivalents of task.

$^{*}p \leq .01$ (two-tailed). $^{**}p \leq .001$ (two-tailed). $^{\dagger}p \leq .05$ (two-tailed).

indicating moderate effect sizes on emotional eating and large effects on mood and self-regulation, occurred up to Month 6, after which there was a partial return toward baseline scores.

For physical activity, there was a significant overall time × group effect, $F(2, 149) = 4.43$, $p = .013$, $\eta_p^2 = .056$. For body composition, there was a significant overall time × group effect, $F(2, 149) = 6.27$, $p = .002$, $\eta_p^2 = .078$. Follow-up t tests indicated that improvements in both physical activity and BMI were significantly greater in Groups 2 and 3 than in Group 1 for each assessed temporal interval (Table 1). With the exception of Group 1, where body composition change from baseline–Month 24 was not significant, within-group t tests indicated significant improvements in both physical activity and body composition for each group, over each assessed temporal interval (Table 1). Calculations of all between-group t tests are given as Online Supplementary Data.

Mediation analyses

The predictions of mood changes by change in emotional eating, and the prediction of emotional eating changes by mood changes (Paths *c*), were significant over each temporal interval tested (Table 2). This suggested consistent reciprocal relationships between changes in emotional eating and mood. Change in self-regulation for controlling eating was a significant mediator in each of the above-mentioned relationships between changes in emotional eating and mood (Table 2).

Moderated mediation analyses

Physical activity level significantly moderated the predictions of mood changes from baseline–Month 6 (95% CI = .007, .132), baseline–Month 12 (95% CI = .002, .161), and baseline–Month 24 (95% CI = .006, .163) that were annotated in the previous mediation models. Treatment emphases on emotional eating change significantly moderated the prediction of emotional eating changes from baseline–Month 6 (95% CI = .011, .073), baseline–Month 12 (95% CI = .019, .091), and baseline–Month 24 (95% CI = .015, .091). The length of treatment significantly moderated the prediction of change in emotional eating from baseline–Month 24 (95% CI = .014, .088), but not change in mood from baseline–Month 24 (95% CI = −.013, .151).

Discussion

The present investigation extended both theory and the knowledge base guiding behavioral intervention processes. It also addressed gaps in the extant research. As expected, significant changes in emotional eating and mood over 3, 6, 12, and 24 months demonstrated reciprocality in their relationships. This suggests a self-perpetuating cycle between mood and emotional eating changes requiring

Table 2. Results of mediation and reciprocal effects analyses ($N = 152$).

Predictor	Mediator	Outcome	Path *c*	Path *a*	Path *b*	Path *c′*	Indirect effect
			β (*SE*) *p*	β (*SE*) *p*	β (*SE*) *p*	β (*SE*) *p*	β (*SE*) [95% CI]
$\Delta_{B\text{-}3}$ Emotional eating	$\Delta_{B\text{-}3}$ Self-regulation	$\Delta_{B\text{-}6}$ Negative mood	.44 (.14) <.001	−.16 (.06) .005	−.50 (.18) .003	.36 (.13) .004	.08 (.04) .025, .167
$\Delta_{B\text{-}3}$ Negative mood	$\Delta_{B\text{-}3}$ Self-regulation	$\Delta_{B\text{-}6}$ Emotional eating	.14 (.05) .003	−.14 (.04) <.001	−.27 (.11) .006	.10 (.05) .022	.04 (.02) .013, .075
$\Delta_{B\text{-}6}$ Emotional eating	$\Delta_{B\text{-}6}$ Self-regulation	$\Delta_{B\text{-}12}$ Negative mood	.36 (.14) .007	−.20 (.06) <.001	−.41 (.20) .020	.27 (.15) .031	.08 (.05) .013, .188
$\Delta_{B\text{-}6}$ Negative mood	$\Delta_{B\text{-}6}$ Self-regulation	$\Delta_{B\text{-}12}$ Emotional eating	.16 (.05) .002	−.12 (.05) <.001	−.32 (.13) .008	.12 (.05) .014	.04 (.02) .031, .211
$\Delta_{B\text{-}12}$ Emotional eating	$\Delta_{B\text{-}12}$ Self-regulation	$\Delta_{B\text{-}24}$ Negative mood	.32 (.12) .003	−.21 (.05) <.001	−.39 (.18) .016	.24 (.12) .024	.08 (.05) .014, .181
$\Delta_{B\text{-}12}$ Negative mood	$\Delta_{B\text{-}12}$ Self-regulation	$\Delta_{B\text{-}24}$ Emotional eating	.17 (.05) .001	−.12 (.03) <.001	−.31 (.13) .008	.13 (.05) .009	.04 (.02) .012, .081

Note: Analyses are based on a bootstrapping method for mediation incorporating 20,000 resamples (Hayes, 2013). Path c = Predictor→Outcome; Path a = Predictor→Mediator; Path b = Mediator→Outcome; Path c′ = Predictor→Outcome, controlling for the mediator. Indirect effect is a measure of significance of mediation. $\Delta_{B\text{-}3}$ = change from baseline–Month 3 (with similar notations for other temporal periods). Significance was set at $p \leq .05$ (one-tailed). 95% CI = 95% confidence interval; SE: standard error.

treatment attention where it has not typically been directed, especially in women with obesity where it might be most relevant (Penéau et al., 2013). Further analyses also supported the hypothesis that improvements in self-regulatory skills development mediate those relationships over both the short term and the long term. This suggests that an unproductive cycle, with implications for reduced control over eating, can be mitigated through self-regulatory skills developed within treatments. The results also suggest the importance of further testing interventions with a greater focus on self-regulatory skills than informing participants on weight loss processes and nuances of a diet (e.g., macronutrient proportions, foods to avoid). Self-regulation effect sizes associated with Groups 2 and 3 were double that of the educational focus of Group 1. This is consistent with both social cognitive theory (Bandura, 1986, 2005) and related treatment-based findings (Annesi, 2012). It should be noted, however, that extending the treatment beyond one year with brief follow-ups did not further increase effects on emotional eating and mood through Year 2. Reasons for this, and how psychosocial predictors of weight control can be extended long term, require further research. Further research is also needed to assess why the educational group obtained the greatest change in emotional eating during the initial six months.

The finding that physical activity moderated the abovementioned effects was also expected, and is consistent with Baker and Brownell's (2000) proposed model of physical activity's influences on psychological factors associated with weight loss. The association of physical activity with mood change has already been well-substantiated (Landers & Arent, 2007). The finding that the length of treatment did not affect mood change is consistent with research suggesting that most changes will occur with the initial three to six months of initiating physical activity (Landers & Arent, 2007). Because adherence to physical activity is challenging for most individuals, evidenced by less than 5% of the overall adult population in the United States completing suggested minimum amounts (Troiano et al., 2008), future weight loss interventions should consider employing strong exercise adherence methodologies that also emphasize self-regulatory skills development (as was the case in Groups 2 and 3 of this study). Carry over of such skills from physical activity to eating changes has been suggested (Oaten & Cheng, 2006), and might prove to be of overall benefit through mechanisms consistent with those indicated within this study. Other moderation analyses within this research supported specifically addressing emotional eating within treatments and having a minimum treatment duration of a full year.

Limitations of this research include a volunteer sample of women of 30 years of age and older. Although this precludes generalization of findings to men and younger women, a case for incorporating the present sample parameters was made earlier in this report. Replications with men, younger ages, specific ethnicities/racial groups, and medical disorders such as diabetes and morbid obesity (i.e., BMI $\geq$ 40 kg/m^2) are, however, still required. Although volunteerism can

affect participant responses within a field research environment (e.g., expectation effects, Hawthorne effect), individuals' initiation into weight management treatments is nearly always by choice. Contrasts with samples where participants are strongly referred to behavioral weight loss treatments by medical practitioners (to limit self-selection bias) might help determine the extent that this confound is associated with the experimental artifact of volunteerism. Although the length of treatment was treated as a moderator variable, it *alone* might have influenced results. Thus, that possibility should be better accounted for in extensions of this research. Additionally, extensions of this research should assess direct effects on nutritional behaviors and subsequent changes in body composition.

In conclusion, it is suggested that behavioral weight loss treatments emphasize self-regulation, attention to mood-based correlates of overeating, support of physical activity, and a treatment duration of at least one year. Within the present findings, each of these had implication for future treatment architectures and effects. Continued research into the psychosocial dynamics of overeating behaviors, with theory driving both research questions and practice implications, is greatly needed. Rapid generalizability of salient findings into treatment settings will also benefit when extensions of this research are again conducted in field settings (Green et al., 2013). As a better understanding of psychosocial correlates of controlled/uncontrolled eating emerges from such research, it is hoped that improved and easily applied treatment protocols can be deployed within large-scale health settings so that many in need might benefit from reduced health risks, an enhanced quality-of-life, and reduced mortality.

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References

Abraham, C., & Michie, S. (2008). A taxonomy of behavior change techniques used in interventions. *Health Psychology*, *27*, 379–387. doi:10.1037/0278-6133.27.3.379

Andrews, R. A., Lowe, R., & Clair, A. (2011). The relationship between basic need satisfaction and emotional eating in obesity. *Australian Journal of Psychology*, *63*, 207–213. doi:10.1111/j.1742-9536.2011.00021.x

Annesi, J. J. (2012). Supported exercise improves controlled eating and weight through its effects on psychosocial factors: Extending a systematic research program toward treatment development. *Permanente Journal*, *16*(1), 7–18.

Annesi, J. J., & Marti, C. N. (2011). Path analysis of exercise treatment-induced changes in psychological factors leading to weight loss. *Psychology and Health*, *26*, 1081–1098. doi:10.1080/08870446.2010.534167

Arnett, J. J., Žukauskienė, R., & Sugimura, K. (2014). The new life stage of emerging adulthood at ages 18-29 years: Implications for mental health. *Lancet Psychiatry*, *1*, 569–576. doi:10.1016/S2215-0366(14)00080-7

Arnow, B., Kenardy, J., & Agras, W. S. (1995). The Emotional Eating Scale: The development of a measure to assess coping with negative affect by eating. *International Journal of Eating Disorders*, *18*, 79–90. doi:10.1002/1098-108X(199507)18:1<79::AID-EAT2260180109>3.0.CO;2-V

Baker, C. W., & Brownell, K. D. (2000). Physical activity and maintenance of weight loss: Physiological and psychological mechanisms. In C. Bouchard (Ed.), *Physical activity and obesity* (pp. 311–328). Champaign, IL: Human Kinetics.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (2005). The primacy of self-regulation in health promotion. *Applied Psychology: An International Review*, *5*, 245–254. doi:10.1111/j.1464-0597.2005.00208.x

Baranowski, T., Lin, L. S., Wetter, D. W., Resnicow, K., & Hearn, M. D. (1997). Theory as mediating variables: Why aren't community interventions working as desired? *Annals of Epidemiology*, *7*(Suppl), S89–S95. doi:10.1016/S1047-2797(97)80011-7

Brownell, K. D. (2004). *The LEARN program for weight management* (10th ed.). Dallas, TX: American Health.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Mahwah, NJ: Erlbaum.

Cooper, Z., Fairburn, C. G., & Hawker, D. M. (2003). *Cognitive-behavioral treatment of obesity: A clinician's guide*. New York, NY: Guilford.

Cromwell, J. B., Hanna, M. J., Labys, W. C., & Terraza, M. (1994). *Multivariate tests for time series models: Quantitative application for the social sciences*. Thousand Oaks, CA: SAGE.

Degenio, A. G., Mancuso, J. P., Gerber, R. A., & Dvorak, R. V. (2009). Comparison of methods for delivering a lifestyle modification program for obese patients. *Annals of Internal Medicine*, *150*, 255–262. doi:10.7326/0003-4819-150-4-200902170-00006

Eldredge, K. L., & Agras, W. S. (1996). Weight and shape overconcern and emotional eating in binge eating disorder. *International Journal of Eating Disorders*, *19*, 71–82. doi:10.1002/(SICI)1098-108X(199601)19:1<73::AID-EAT9>3.0.CO;2-T

Elmore, D. K., & de Castro, J. M. (1990). Self-rated moods and hunger in relation to spontaneous eating behavior in bulimics, recovered bulimics, and normal. *International Journal of Eating Disorders*, *9*, 179–190. doi:10.1002/1098-108X(199003)9:2<179::AID-EAT2260090207>3.0.CO;2-O

Federal Trade Commission. (2018). *Weighing the claims in diet ads*. Washington, DC: Federal Trade Commission. Retrieved from https://www.consumer.ftc.gov/articles/0061-weighing-claims-diet-ads

Glymour, M. M., Weuve, J., Berkman, L. F., Kawachi, I., & Robins, J. M. (2005). When is baseline adjustment useful in analyses of change? An example with education and

cognitive change. *American Journal of Epidemiology*, *162*, 267–278. doi:10.1093/aje/kwi187

Godin, G. (2011). The Godin-Shephard Leisure-Time Physical Activity Questionnaire. *Health and Fitness Journal of Canada*, *4*(1), 18–22.

Godin, G., & Shephard, R. J. (1985). A simple method to assess exercise behavior in the community. *Canadian Journal of Applied Sport Science*, *10*, 141–146.

Goldbacher, E. M., Grunwald, H. E., LaGrotte, C. A., Klotz, A. A., Oliver, T. L., Musliner, K. L., . . . Foster, G. D. (2012). Factor structure of the Emotional Eating Scale in overweight and obese adults seeking treatment. *Appetite*, *59*, 610–615. doi:10.1016/j.appet.2012.04.005

Greaves, C. J., Sheppard, K. E., Abraham, C., Hardeman, W., Roden, M., Evans, P. H. . . . The IMAGE Study Group. (2011). Systematic review of reviews of intervention components associated with increased effectiveness in dietary and physical activity interventions. *BMC Public Health*, *11*, 119. doi:10.1186/1471-2458-11-119

Green, L. W., Sim, L., & Breiner, H. (Eds). (2013). *Evaluating obesity prevention efforts: A plan for measuring progress*. Washington, DC: Institute of Medicine of the National Academies.

Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. D. (2010). Ego depletion and the strength model of self-control: A meta-analysis. *Psychological Bulletin*, *136*, 495–525. doi:10.1037/a0019486

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. New York, NY: Guilford.

Hayes, A. F. (2015). An index and test of linear moderated mediation. *Multivariate Behavioral Research*, *50*, 1–22. doi:10.1080/00273171.2014.962683

Jacobs, D. R., Ainsworth, B. E., Hartman, T. J., & Leon, A. S. (1993). A simultaneous evaluation of 10 commonly used physical activity questionnaires. *Medicine and Science in Sports and Exercise*, *25*, 81–91.

Jeffery, R. W., Drewnowski, A., Epstein, L. H., Stunkard, A. J., Wilson, G. T., Wing, R. R., & Hill, D. R. (2000). Long-term maintenance of weight loss: Current status. *Health Psychology*, *19*(Suppl), 5–16. doi:10.1037/0278-6133.19.Suppl1.5

Jetté, M., Sidney, K., & Blumchen, G. (1990). Metabolic equivalents (METs) in exercise testing, exercise prescription and evaluation of functional capacity. *Clinical Cardiology*, *13*, 555–565. doi:10.1002/clc.4960130809

Johnson, P. H., & Annesi, J. J. (2018). Factors related to weight gain/loss among emerging adults with obesity. *American Journal of Health Behavior*, *42*, 3–16. doi:10.5993/AJHB.42.3.1

Jones, L. R., & Wadden, T. A. (2006). State of the science: Behavioral treatment of obesity. *Asia Pacific Journal of Clinical Nutrition*, *15*(Suppl 1), 30–39.

Kaiser Permanente Health Education Services. (2008). *Cultivating Health weight management kit* (8th ed.). Portland, OR: Kaiser Permanente.

Koenders, P. G., & van Strien, T. (2011). Emotional eating, rather than lifestyle behavior, drives weight gain in a prospective study in 1562 employees. *Journal of Environmental Medicine*, *53*, 1287–1293. doi:10.1097/JOM.0b013e31823078a2

Landers, D. M., & Arent, S. M. (2007). Physical activity and mental health. In G. Tennenbaum & R. C. Eklund (Eds), *Handbook of sport psychology* (3rd ed., pp. 469–491). New York, NY: Wiley.

Lang, A., & Froelicher, E. S. (2006). Management of overweight and obesity in adults: Behavioral intervention for long-term weight loss and maintenance. *European Journal of Cardiovascular Nursing*, *5*, 102–114. doi:10.1016/j.ejcnurse.2005.11.002

Lemmens, V. E., Oenema, A., Klepp, K. I., Henriksen, H. B., & Brug, J. (2008). A systematic review of the evidence regarding efficacy of obesity prevention interventions among adults. *Obesity Reviews*, *9*, 446–455. doi:10.1111/j.1467-789X.2008.00468.x

Loveman, E., Frampton, G. K., Shepherd, J., Picot, J., Cooper, K., Bryant, J., . . . Clegg, A. (2011). The clinical effectiveness and cost-effectiveness of long-term weight management schemes for adults: A systematic review. *Health Technology Assessment*, *15*(2), 1–82. doi:10.3310/hta15020

MacLean, P. S., Wing, R. R., Davidson, T., Epstein, L., Goodpaster, B., Hall, K. D., . . . Ryan, D. (2015). NIH working group report: Innovative research to improve maintenance of weight loss. *Obesity*, *23*, 7–15. doi:10.1002/oby.20967

Mann, T., Tomiyama, J., Westling, E., Lew, A. M., Samuels, B., & Chatman, J. (2007). Medicare's search for effective obesity treatments: Diets are not the answer. *American Psychologist*, *62*, 220–233. doi:10.1037/0003-066X.62.3.220

Mata, J., Silva, M. N., Vieira, P. N., Carraça, E. V., Andrade, A. M., Coutinho, S. R., . . . Teixeira, P. J. (2009). Motivational "spill-over" during weight control: Increased self-determination and exercise intrinsic motivation predict eating self-regulation. *Health Psychology*, *28*, 709–716. doi:10.1037/a0016764

McNair, D. M., & Heuchert, J. W. P. (2009). *Profile of Mood States technical update*. North Tonawanda, NY: Multi-Health Systems.

Miller, D. J., Freedson, P. S., & Kline, G. M. (1994). Comparison of activity levels using Caltrac accelerometer and five questionnaires. *Medicine and Science in Sports and Exercise*, *26*, 376–382.

Oaten, M., & Cheng, K. (2006). Longitudinal gains in self-regulation from regular physical exercise. *British Journal of Health Psychology*, *11*, 717–733. doi:10.1348/135910706X96481

Palmeira, A. L., Markland, D. A., Silva, M. N., Branco, T. L., Martins, S. C., Minderico, C. S., . . . Teixeira, P. J. (2009). Reciprocal effects among changes in weight, body image, and other behavioral factors during behavioral obesity treatment: A mediation analysis. *International Journal of Behavioral Nutrition and Physical Activity*, *6*, Article 9. doi:10.1186/1479-5868-6-9

Penéau, S., Ménard, E., Méjean, C., Bellisle, F., & Hercberg, S. (2013). Sex and diet modify the association between emotional eating and weight status. *American Journal of Clinical Nutrition*, *97*, 1307–1313. doi:10.3945/ajcn.112.054916

Saelens, B. E., Gehrman, C. A., Sallis, J. F., Calfas, K. J., Sarkin, J. A., & Caparosa, S. (2000). Use of self-management strategies in a 2-year cognitive-behavioral intervention to promote physical activity. *Behavior Therapy*, *31*, 365–379. doi:10.1016/S0005-7894(00)80020-9

Schafer, J. L., & Graham, J. W. (2002). Missing data: Our view of the state of the art. *Psychological Methods*, *7*, 147–177. doi:10.1037/1082-989X.7.2.147

Simpson, S. A., Shaw, C., & McNamara, R. (2011). What is the most effective way to maintain weight loss in adults? *British Medical Journal*, *343*, d8042. doi:10.1136/bmj.d8042.

Singer, J. D., & Willet, J. B. (2003). *Applied longitudinal data analysis: Modeling change and event occurrence*. New York, NY: Oxford University Press.

Stoeckel, L. E., Birch, L. L., Heatherton, T., Mann, T., Hunter, C., Czajkowski, S., . . . Savage, C. R. (2017). Psychological and neural contributions to appetite regulation. *Obesity*, *25*(Suppl 1), S17–S25. doi:10.1002/oby.21789

Suresh, K. P. (2011). An overview of randomization techniques: An unbiased assessment of outcome in clinical research. *Journal of Human Reproductive Sciences*, *4*, 8–11. doi:10.4103/0974-1208.82352

Teixeira, P. J., Carraça, E. V., Marques, M. M., Rutter, H., Oppert, J. M., De Bourdeaudhuij, I., . . . Brug, J. (2015). Successful behavior change in obesity interventions in adults: A systematic review of self-regulation mediators. *BMC Medicine*, *13*, 84. doi:10.1186/s12916-015-0323-6

Teixeira, P. J., Silva, M. N., Coutinho, S. R., Palmeira, A. L., Mata, J., Carraça, E. V., . . . Sardinha, L. B. (2010). Mediators of weight loss and weight loss maintenance in middle-aged women. *Obesity*, *18*, 725–735. doi:10.1038/oby.2009.281

Troiano, R. P., Berrigan, D., Dodd, K. W., Mâsse, L. C., Tilert, T., & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine and Science in Sports and Exercise*, *40*, 181–188. doi:10.1249/mss.0b013e31815a51b3

U.S. Department of Health and Human Services. (2008). *2008 Physical activity guidelines*. Retrieved from https://health.gov/paguidelines/guidelines/

White, I. R., Horton, N. J., Carpenter, J., & Pocock, S. J. (2011). Strategy for intention to treat data in randomized trials with missing outcome data. *British Medical Journal*, *342*, d40. doi:10.1136/bmj.d40.

Wing, R. R., & Hill, J. O. (2001). Successful weight loss maintenance. *Annual Review of Nutrition*, *21*, 323–341. doi:10.1146/annurev.nutr.21.1.323

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