Research and Best Practice

Reciprocal effects of changes in mood and self-regulation for controlled eating associated with differing nutritional treatments in severely obese women

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Abstract

Background Weight-loss interventions have had disappointing outcomes, partly because of a minimal understanding of associated psychological factors. Theory-based treatments often seek to build self-regulation for controlling eating – a strong predictor of weight loss. Mood changes associated with treatment may, however, affect self-regulatory changes in obese women. Self-regulatory changes may, reciprocally, impact mood. Consequently, the aim of this study was to (a) assess treatment-associated effects on depression, total negative mood, and self-regulatory skills usage, and (b) determine whether changes in mood mediate self-regulatory skill changes, and vice-versa.

Methods Women with severe obesity were randomly assigned to groups of exercise support plus either nutrition education (n = 134) or cognitive behavioral methods emphasizing the building of self-regulation skills for eating (n = 135). In addition to exercise support, the nutrition groups met every 2 weeks for 3 months, with follow-up after 6 months.

Results Significant overall improvements in self-regulation, depression, and total mood disturbance were found over 6 months, with changes in total mood disturbance and self-regulation significantly greater in the cognitive-behavioral treatment group. Because the mediating effects of mood changes on the relationship of treatment type and changes in self-regulation were significant, as was the mediation of self-regulation change in the treatment-mood change relationships, the criteria for reciprocal effects was met. For participants with high total mood disturbance scores, changes in total mood disturbance and self-regulation completely mediated the treatment-self-regulation and treatment-mood relationships, respectively. Post hoc testing indicated significant associations between participants' exercise volume and improvements in their mood scores.

Conclusion Because treatment-induced changes in mood and self-regulation for eating may have reciprocal effects, methods for improving both should be incorporated in weight-loss treatments for obese women. Moderate physical activity may be a method for improving mood.

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Introduction

Results from behavioral weight management treatments have been disappointing (1). It is thought that after initially reinforcing effects (e.g., complements from peers, ongoing progress viewed on one's scale), individuals become less able to self-regulate their eating through the many barriers typically encountered (e.g., social pressure to eat, boredom, easily available "fast foods") (2). Additionally, the physiological response of their reduced weight plateauing can be discouraging, and trigger relapses into old eating patterns (and weight regain). Although typical weight-loss treatments continue to focus on educating individuals on healthy eating practice, both theory and research have not supported the efficacy of that approach (1). Cognitive-behavioral methods that emphasise specific self-regulatory skills (e.g., attending to cues to eating, cognitive restructuring) have emerged from social cognitive and self-efficacy theories (3;4), and are performing better than educational approaches (5;6). However, results are still minimal and inconsistent, and reasons for any positive behavioral effects have been both unclear and understudied.

Another psychological factor that may affect overeating, especially in women, is mood (7). Emotions may not only trigger inappropriate eating, they may undermine all important self-regulatory abilities (that are already challenged for most individuals). For example, research suggests that improvements in "... variables such as depression and anxiety could

lead to a healthier psychological climate in which individuals have more cognitive and emotional resources [to continue to self-regulate through barriers]…" (7, p 320). This suggested a need for a better understanding of how such psychosocial factors, previously indicated to be associated with eating, may interact with one another (9).

The use of physical activity in weight management has been an area of increased interest (1). Although commonly used as an adjunct to nutritional weight-loss treatments because of its obvious effect on caloric expenditure, researchers have recently suggested its additional (possibly greater) improvements in self-regulation to eating behaviors (2;10;11). For example, self-regulatory skills nurtured within a context of adherence to exercise might then "carry over" to help control eating. Physical activity, even in volumes of as little as 2 moderate sessions per week (2;12), have been associated with improvements in depression, anxiety, and overall mood in individuals both with and without initially low mood (13), and may positively affect emotional eating (2). Although understanding whether emotional eating is actually induced by decrements in mood "breaking down" self-regulatory skills, and/or if change in self-regulation impacts mood (and the possible role of physical activity affecting each of those relationships) is of critical importance for effective treatment, surprisingly, little corresponding research is available.

Because researchers acknowledge a minimal understanding of psychosocial factors' role in nutritional weight-loss treatments (8) – sometimes even questioning the viability of continuing behavioral obesity treatment research at all (because of such poor results persisting for so long) (14) – this study was conducted. Specifically, we tested a sample of severely obese, sedentary women initiating physical activity and enrolled in either a nutrition education treatment, or a treatment emphasising self-regulation for controlled eating, to (a) assess associated effects on depression, total negative mood, and self-regulatory skills usage, and (b) determine whether treatment-induced changes in mood mediate self-regulatory skill changes, and vice-versa. We hypothesized that we would find significant improvements in each psychological variable studied; and that changes in self-regulation would be mediated by mood changes, and changes in mood would mediate self-regulatory skill change (i.e., a reciprocal relationships). It was thought that a better understanding of how treatment-induced changes in self-regulation and mood interact could provide useful data for much-needed improvements in weight-loss treatments.

Methods

Participants

Women responded to advertisements in the local print media for an investigation into exercise and nutrition methods for weight management at a local YMCA. Inclusion criteria were: age ≥ 21 years, BMI between 35 and 55 kg/m², and no regular exercise (less than 20 minutes/week average) in the past year. Exclusion criteria were: present or planned pregnancy and/or current use of medications for weight loss or a psychological condition. A physician-endorsed statement of adequate physical health for participation was required. Institutional review board approval and written consent from all participants was obtained. After minimal attrition due to self-reported problems with transportation (n = 2), illness (n = 2), and not returning phone calls or emails (n = 3), there was no significant difference in age (overall M = 42.9 years, SD = 9.9), BMI (overall M = 41.2 kg/m², SD = 5.1), and racial make-up (overall 44% white, 51% african American, and 5% of other racial/ethnic groups) between participants randomly assigned to a treatment of supported exercise plus either standard nutrition education (n = 134) or cognitive-behavioral nutrition methods emphasising self-regulation (n = 135). Most participants (94%) were classified as middle-class.

Measures

A previously validated scale (15) was adapted to measure self-regulatory skill usage for controlled eating. As suggested by its developers, the revision was based on the self-regulation skills addressed within this study. Possible responses to its 10 items (e.g., "I say positive things to myself about eating well.") ranged from 1 (never) to 5 (often). Internal consistency was α = .81, and test-retest reliability over 2 weeks was .74 (11).

Two scales from the Profile of Mood States Short Form (16) were used. Total mood disturbance is an aggregate measure of tension, depression, fatigue, confusion, anger, and vigor (30 items total). Depression was also measured separately (5 items; e.g., "sad", "dejected"). Possible responses to items ranged from 0 (not at all) to 4 (extremely). Internal consistencies ranged from α = .84-.95 (.95 for depression), and test-retest reliability at 3 weeks averaged .69 (.74 for depression) (16). Concurrent validity was suggested through contrasts with well-accepted measures such as the Beck Depression Inventory, Manifest Anxiety Scale, and Minnesota Multiphasic Personality Inventory (16).

The Godin Leisure-Time Exercise Questionnaire (17) measured volume of physical activity over the last week. Frequencies of strenuous ("heart beats rapidly"; e.g., running), moderate ("not exhausting"; e.g., fast walk-

ing), and light ("minimal effort;" e.g., easy walking) physical activities occurring for at least 15 minutes per session are entered, multiplied by 9, 5, and 3 standard metabolic equivalents (METs) (18), respectively, and then summed. Test-retest reliability over 2 weeks was .74 (17). Construct validity was supported by significant correlations of questionnaire scores with other measures of exercise output (i.e., accelerometer and maximum volume of oxygen consumption scores) (19;20).

Procedure

Each participant reported to an assigned YMCA center and received a group orientation to study processes. The physical activity support component was identical for each of the 2 treatment groups. It consisted of a standard protocol of six 1-hour meetings (approximately monthly) with a trained wellness specialist over 6 months (11). These one-on-one sessions included an orientation to exercise apparatus, goal setting, and review of self-management methods intended to support adherence. Physical activity plans were based on each participant's preference. Standard recommendations of 150 minutes/week of moderate cardiovascular activity (21) were described; however, the benefit from any increase in physical activity was also indicated.

The nutrition treatment components differed by group. The nutrition education treatment emphasized education in healthy eating practices. The cognitive-behavioral nutrition treatment emphasised the use of self-regulation skills to control eating. Each had six 1-hour sessions administered by a certified wellness specialist in group format of 10 to 15 participants over approximately 3 months. In the nutrition education treatment, the standardised protocol used included: (a) understanding macronutrients and calories, (b) healthy recipes, (c) menu planning, (d) low-fat snacking, and (e) stocking a healthy kitchen (22). In the cognitive-behavioral nutrition treatment group, the protocol administered included: (a) establishing daily caloric goals and logging foods along with their associated calories, (b) thought stopping, (c) cognitive restructuring, (d) relapse prevention training, (e) attending to cues to overeating, (f) barrier identification, and (g) behavioral contracting. Wellness specialists who were trained to administer the treatments had YMCA and other national health and fitness certifications, and were blind to the purposes of the study. Treatment fidelity was assessed by senior wellness staff members under the direction of the study staff. Assessments were administered at baseline and month 6.

Data analysis

The intention-to-treat design incorporated in the expectation-maximisation algorithm (23) to impute data for the 15% of missing scores. Statistical significance was set at $\alpha = .05$ (2-tailed). To detect a small effect ($f^2 = .05$) at the statistical power of .80 ($\alpha = .05$), a minimum of 193 participants was needed. Mixed model repeated measure ANOVAs (time × treatment type) simultaneously assessed whether score changes were significant over 6 months, and whether those changes differed by treatment type. Based on previous suggestions (24), unadjusted score changes were calculated. Effect sizes were expressed as either Cohen's d or partial eta-squared (η^2_p) where .20, .50, and .80; and .01, .06, and .14 represent small, moderate, and large effects, respectively. Collinearity was tested through multiple regression analyses predicting self-regulation changes. The associated variance inflation factors (1.01-1.03) and tolerances (.97-.99) were well within acceptable limits.

Mediation models (Figure 1) were derived using a bias-corrected bootstrapping procedure incorporating 10,000 re-samples (25). Thus, normally distributed data were not required. Because of their significant bivariate correlations with change scores, baseline scores were entered as covariates. If the relationship of the predictor and outcome variable (path c) changed from statistically significant to non-significant after entry of the mediator (path c′), then complete mediation was considered to be present. Utilising the above mediation analysis procedure, and based on recent research (26), a series of reciprocal effects analyses were computed that assessed the presence/non-presence of reciprocal effects of changes in depression or total mood disturbance, with self-regulation for eating changes, resulting from the 2 treatment conditions. A reciprocal effect is considered present if significant mediation is concurrently found in each of 2 complementary equations; the first equation where a psychosocial variable is entered as the outcome (i.e., dependent variable), and the second where that same variable is entered as the mediator (26). For example, in the first reciprocal effects analysis, the first equation had self-regulation change entered as the outcome variable, and change in depression score entered as the mediator. In the second equation of the same analysis, change in depression was the outcome variable and self-regulation change was the mediator. The same procedure was then followed in the second reciprocal effects analysis where change in total mood disturbance was, instead, the mood measure of interest. Finally, the same mediation and reciprocal effects analyses were completed, separately, for participants with high depression and high total mood disturbance scores. Based on previous research (27;28), high depression and high total mood disturbance was defined as a baseline score of at least 1.5 SD above the normative mean for the corresponding measure (16;29).

Post hoc testing was conducted to determine if (a) change in weekly volume of physical activity, (b) mean volume of physical activity, and (c) presence/absence of a volume of physical activity equivalent to at least 2 sessions per week (i.e., ≥ 10 METs/week average over the duration of the investigation) was significantly related to change in depression and/or total mood disturbance score (see Table 1 for data on physical activity volumes at baseline and month 6).

Results

Descriptive statistics of scores of self-regulation for controlled eating, depression, and total mood disturbance at baseline and month 6, their mean change scores, and corresponding effect sizes are given in Table 1. There were no significant differences between the treatment types at baseline in any of the measures (p-values > .14). Significant effects for time were found for each measure

Figure 1 Mediation models

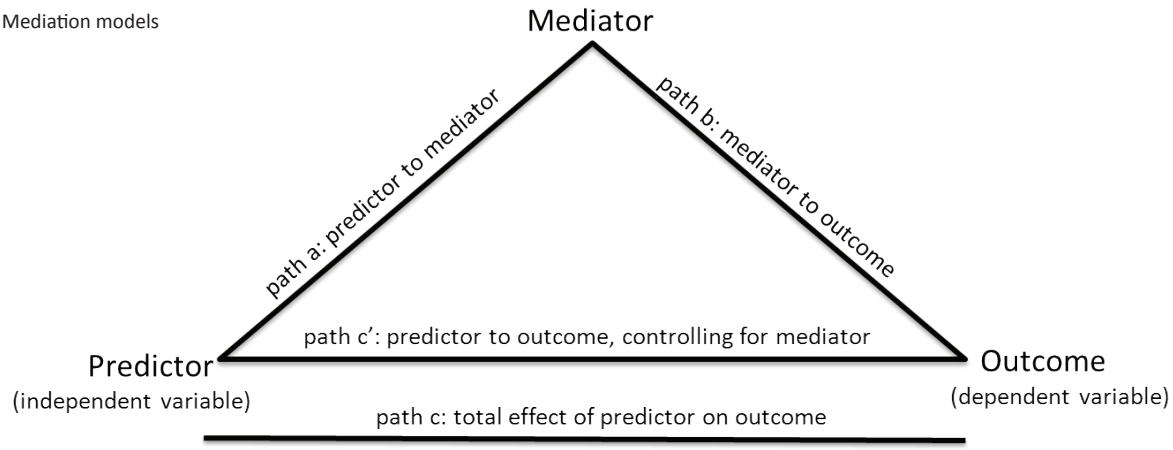

Table 1 Changes in study measures over 6 months

	Baseline		Month 6		Change		
	M	SD	M	SD	d	M	SD
Self-regulation for controlled eating							
Nutrition education group	21.76	5.84	25.16	6.76	.58	3.40	5.44
Cognitive-behavioral nutrition group	22.27	5.46	29.07	6.85	1.25	6.80	6.60
Aggregated data	22.01	5.65	27.12	7.07	.90	5.10	6.28
Depression							
Nutrition education group	4.71	4.31	3.77	3.95	.22	-0.94	2.84
Cognitive-behavioral nutrition group	3.99	3.62	2.56	3.05	.39	-1.42	2.98
Aggregated data	4.35	3.99	3.16	3.57	.30	-1.18	2.91
Total mood disturbance							
Nutrition education group	24.00	16.96	15.72	18.93	.49	-8.28	14.60
Cognitive-behavioral nutrition group	22.12	16.97	8.43	17.12	.81	-13.69	16.47
Aggregated data	23.05	16.96	12.06	18.38	.65	-10.99	15.77
Physical activity (METs)							
Nutrition education group	8.94	9.57	20.88	18.22	1.25	11.94	16.00
Cognitive-behavioral nutrition group	9.20	9.21	28.40	17.80	2.08	19.20	17.63
Aggregated data	9.07	9.38	24.65	18.37	1.66	15.58	17.20

Abbr.: M = mean; SD = standard deviation; d = Cohen's effect size for within-group changes: $M_{month\ 6} - M_{baseline} / SD_{baseline}$
Nutrition education group n = 134; Cognitive-behavioral nutrition group n = 135

(p-values < .001), indicating overall significant improvements. There was a significant time × treatment interaction found for self-regulation ($F_{1, 267} = 21.28$, $p < .001$, $\eta^2_p = .07$) and total mood disturbance ($F_{1, 267} = 8.14$, $p = .01$, $\eta^2_p = .03$), indicating greater improvements associated with the cognitive-behavioral nutrition treatment. That interaction term did not reach statistical significance for depression ($F_{1, 267} = 1.82$, $p = .18$, $\eta^2_p = .01$).

Table 2 displays results from the reciprocal effects analyses (see Figure 1). In the first reciprocal effects analysis, change in depression significantly mediated the relationship between treatment type and change in self-regulation for controlled eating; and change in self-regulation significantly mediated the relationship between treatment type and change in depression (complete mediation). Thus, results were consistent with the presence of a reciprocal effect between changes in depression and self-regulation (emanating from treatment type). In the second reciprocal effects analysis, change in total mood disturbance significantly mediated the relationship between treatment type and change in self-regulation; and change in self-regulation significantly mediated the relationship between treatment type and change in total mood disturbance (complete mediation). Therefore, results indicated a reciprocal effect between changes in total mood disturbance and self-regulation (resulting from treatment type).

For participants with a high depression score (n = 34), although change in self-regulation significantly mediated the relationship between treatment type and depression change (noting that a significant relationship between treatment and change in depression was not found; path c, p = .14), depression change did not significantly mediate the treatment-self-regulation change relationship. Thus, a reciprocal effect between changes in depression and self-regulation (derived from treatment type) was not detected. For participants with a high mood disturbance score (n = 34), change in total mood disturbance was a significant mediator of the treatment-self-regulation change relationship; and change in self-regulation

Table 2 Results from mediation and reciprocal effects analyses

Predictor	Mediator	Outcome	*Path a Coef*		*Path b Coef*		*Path c Coef*		*Path c' Coef*		*Indirect effect Coef*		*Model R^2*
			(SE)	p	(SE)	p	(SE)	p	(SE)	p	(SE)	95% CI	p
All participants (N = 269)													
Treatment	ΔDepression	ΔSelf-regulation	*-.75* (.31)	.01	*-.87* (.13)	<.001	*3.58* (.70)	<.001	*2.93* (.66)	<.001	*.65* (.30)	.12, 1.28	*.29* <.001
Treatment	ΔSelf-regulation	ΔDepression	*3.58* (.70)	<.001	*-.17* (.02)	<.001	*-.75* (.31)	.01	*-.16* (.30)	.59	*.59* (.14)	-.92, -.35	*.37* <.001
Treatment	ΔTotal mood disturbance	ΔSelf-regulation	*-6.07* (1.76)	.01	*-.23* (.02)	<.001	*3.58* (.70)	<.001	*2.21* (.59)	<.001	*1.37* (.43)	.55, 2.24	*.44* <.001
Treatment	ΔSelf-regulation	ΔTotal mood disturbance	*3.58* (.70)	<.001	*-1.42* (.13)	<.001	*-6.07* (1.76)	.001	*-1.01* (1.52)	.51	*-5.07* (1.06)	-7.30, -3.10	*.44* <.001
High depression scores (n = 34)													
Treatment	ΔDepression	ΔSelf-regulation	*-2.38* (1.58)	.14	*-.84* (.15)	<.001	*4.52* (1.86)	.02	*2.51* (1.36)	.08	*2.01* (1.44)	-.88, 4.78	*.62* <.001
Treatment	ΔSelf-regulation	ΔDepression	*4.52* (1.86)	.02	*-.61* (.11)	<.001	*-2.38* (1.58)	.14	*-.37* (1.22)	.77	*-2.75* (1.23)	-5.18, -.29	*.55* <.001
High total mood disturbance scores (n = 34)													
Treatment	ΔTotal mood disturbance	ΔSelf-regulation	*-18.62* (6.95)	.01	*-.27* (.03)	<.001	*5.55* (2.17)	.02	*.52* (1.24)	.68	*5.03* (1.99)	.91, 8.90	*.79* <.001
Treatment	ΔSelf-regulation	ΔTotal mood disturbance	*5.55* (2.17)	.02	*-2.76* (.29)	<.001	*-18.62* (6.94)	.01	*-3.32* (3.92)	.40	*-15.30* (5.99)	-27.44, -3.45	*.79* <.001

Abbr.: Coef = coefficient; 95% CI = 95% confidence interval; the Delta symbol (Δ) denotes score change from baseline to month 6
Path a = predictor → mediator; Path b = mediator → outcome; Path c = predictor → outcome;
Path c' = predictor → outcome, controlling for the mediator

was a significant mediator of the relationship between treatment and total mood disturbance change (with both equations demonstrating complete mediation). Thus, findings suggested a reciprocal effect between changes in total mood disturbance and self-regulation (resulting from treatment type).

Linear bivariate correlations of each measure of physical activity volume with depression change were significant (r-values = -.27, -.25, and -.26, respectively, p-values < .001). Relationships of physical activity volumes with change in total mood disturbance were, similarly, each significant (r-values = -.49, -.35, and -.35, respectively, p-values < .001). For participants with a high depression score, corresponding r-values were -.60 (p < .001), -.32 (p = .06), and -.58 (p < .001). For participants with a high mood disturbance score, corresponding r-values were -.69, -.58, and -.62, respectively (p-values < .001).

Discussion

Results provided an increased understanding of behavioral treatment-associated effects on self-regulation for controlled eating, and mood; and how such changes might affect each other. Consistent with previous research (27;28), changes in physical activity, even at a volume equivalent to only 2 moderate sessions per week, was associated with significantly reduced depression and total mood disturbance scores over this 6-month trial with severely obese women. The addition of cognitive-behavioral methods that emphasised self-regulatory skills for eating was, predictably, associated with more improvement in self-regulation than a treatment based on education in appropriate nutritional practices. It should, however, be noted that moderate effects were found for self-regulation changes in the nutrition education group also. Thus, because self-regulation is such a key component of eating behavior change (2), research focusing upon it spontaneously benefiting from establishment of a program of physical activity requires extension (10).

As expected, changes in self-regulation were significantly mediated by depression and total mood disturbance changes. This is in agreement with research suggesting both the empowering (for improvements in mood) and destructive (for decrements in mood) effects of mood on self-regulation (8). Reciprocal effects were identified through, additionally, establishing the mediating effects of changes in self-regulation on depression changes. Although the mediation models corresponding to these findings explained a significant portion of the overall variances, they were especially strong when only participants with high depression and high total mood disturbance were considered. For these participants, however, analyses incorporating total mood disturbance, but not depression, demonstrated reciprocal effects.

Treatment implications emerging from these findings are considerable. For example, the importance of mood change on self-regulation appeared to be quite clear. Because physical activity is a behavior consistent with weight management, and positively affects mood, it should be emphasised within treatments. Because adherence rates for exercise are problematic, and obese individuals may be especially uncomfortable partaking in it (2), volumes may be limited so that adherence and mood change, rather than high energy expenditures, are primary goals. Instruction and rehearsal in self-regulation for controlled eating also seems essential for inclusion in treatments. Possibly, these may be specifically nurtured through teaching similar behavioral skills applied to physical activity (to promote carry-over of these skills to better control eating behaviors). To impact mood, possibly self-regulation skills may also seek to identify, and act on, low mood (e.g., within cognitive restructuring).

Limitations of this investigation should, however, be noted. The use of change (gain) scores inflated the measurement error of the scales by combining error from measurements at both baseline and month 6. Accounting for the dynamic process of changes in the psychosocial factors of mood and self-regulation over the course of the study was, however, an important aspect of this research. Although both mood scales used were deemed to be important, it should be noted that the depression scale was embedded within the measure of total mood disturbance; thus there was, undoubtedly, conceptual overlap between them. Replication with different sample types (males, across degrees of overweight, cancer survivors, individuals with diabetes) are needed to increase confidence in findings, or help to determine if separate predictive models are required (e.g., between men and women). While expectation and social support effects can bias findings within any field-based investigation, the ability to readily generalise findings to applied settings might, overall, be considered an advantage (30).

In summary, addressing previously suggested analytic goals (9) served to extend theory on the relationship of psychosocial factors in weight-loss treatment. Specifically, the use of recently suggested methods of reciprocal effects analysis (26) indicated interrelationships of changes in measures of mood and self-regulation for eating, resulting from treatments with distinctly different emphases. As this area of research advances, psychosocial variables found to be predictive of improved

weight management may facilitate more effective behavioral treatments.

Contribution Details

All authors read and met the ICMJE criteria for authorship and agree with the results and conclusions. JJA designed the study and analysed the data. JJA and KJP contributed to the interpretation of the data and wrote the report.

Competing interests

None declared.

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