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Effects of Two Cognitive-behavioral Physical Activity and Nutrition Treatments on Psychosocial Predictors of Changes in Fruit/Vegetable and High-fat Food Intake, and Weight

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EFFECTS OF TWO COGNITIVE-BEHAVIORAL PHYSICAL ACTIVITY AND NUTRITION TREATMENTS ON PSYCHOSOCIAL PREDICTORS OF CHANGES IN FRUIT/VEGETABLE AND HIGH-FAT FOOD INTAKE, AND WEIGHT

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***Abstract*:** Improved mood may increase the consumption of healthy foods and decrease the intake of unhealthy foods. Increased physical activity might improve mood and, thus, eating behaviors. Adults (M_{age} = 45 years) with severe and morbid obesity ($M_{body\ mass\ index}$ = 41kg/m^2) were randomly assigned to 6 months of either cognitive-behavioral physical activity and nutrition-support methods alone (*n* = 92), or those methods plus mood regulation training (*n* = 92). There were significant improvements in physical activity, mood, self-regulation and self-efficacy for controlling eating, and weight that did not differ by group. Improvement in mood was associated with greater fruit/vegetable intake. Change in self-efficacy significantly mediated that relationship. Only two sessions of moderate physical activity/week were required to improve mood. Findings have implications for weight-loss intervention improvement.

***Key words*:** Cognitive-behavioral training, Mood, Nutrition support, Obesity, Physical activity.

Prevalence of obesity in the United States has been on the rise for many years (Flegal, Carroll, Ogden, & Curtin, 2010), with severe or Grade 2 obesity (body mass index [BMI] ≥ 35 < 40 kg/m^2) and morbid or Grade 3 obesity (BMI ≥ 40 kg/m^2) having the greatest risks for heart disease, type 2 diabetes, and some forms of cancer (U.S. Department of Health and Human Services, 2008; Wyatt, Winters, & Dubbert, 2006). Approximately 70% of the U.S. population is now either overweight or obese, with only

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2 in 10 African American and Hispanic adults of ages 40 years and above at a healthy weight (Flegal et al., 2010). At any given time, about half of adults are trying to lose weight (Bish et al., 2005). Poor eating behaviors (e.g., diets high in fats and low in fruits and vegetables) are considered primary causal factors of the obesity epidemic, and are difficult to change (Wyatt et al., 2006).

Previous treatment models

Behavioral interventions for weight loss have typically been unsuccessful beyond the very short term (Mann et al., 2007). Given the evidence of repeated intervention failures, some researchers suggest that behavioral techniques might not be useful for weight reduction (Cooper et al., 2010). They conclude that we should, "... shift away from work on [obesity] treatment and instead focus on prevention." (Cooper et al., 2010, p. 712). Others, however, feel that the development and testing of innovative helping methods remain both warranted and necessary (Annesi & Marti, 2011; Annesi & Porter, 2013; Jeffery et al., 2000; Mann et al., 2007). Cognitive-behavioral methods for nutrition change that emphasize the use of self-regulatory skills (e.g., dealing with cues to eating, tracking foods consumed) to manage barriers to healthy eating, and thus foster feelings of accomplishment and self-efficacy associated with incremental progress, have been the most promising to-date (Diabetes Prevention Program Research Group, 2009; Teixeira et al., 2002; Wing, Tate, Raynor, & Fava, 2006). They too, however, have demonstrated mostly transient effects (Cooper et al., 2010). Creative extensions of cognitive-behavioral approaches might, however, be the most likely to have merit in the future (Jeffrey et al., 2000).

Physical activity in weight loss

Physical activity is the strongest predictor of long-term success with weight loss (Fogelholm & Kukkomen-Harjula, 2000; Svetkey et al., 2008); however, its use has typically been limited to supplementation of a primary focus of severe caloric restriction. In their comprehensive review, Mann and her colleagues (2007) suggested that physical activity might hold promise for the architecture of more productive obesity interventions beyond that of its associated caloric expenditure (which is minimal in obese and unfit individuals because of their inability to tolerate much physical exertion; American College of Sports Medicine, 2009). Jeffrey and colleagues (2000) suggested evaluation of the mechanisms through which physical activity has its effects, and then addressing the question "Can these effects be enhanced to improve long-term weight outcomes?" (p. 14).

Mood and eating behaviors

Some (Konttinen, Männistö, Sarlio-Lähteenkorva, Silventoinen, & Haukkala, 2010; Macht, 2008; Oliver, Wardel, & Gibson, 2000), but not all (Lluch, Herbeth, Mejean, & Siest, 2000), cross-sectional studies suggest that a more positive mood is associated with greater intake of fruits and vegetables, and more negative mood is associated with greater intake of sweets and fats (Lai et al., 2013). This might be linked to increased neurological sensitivities to the reinforcement effects of fatty foods in those with more negative mood (Gibson, 2006). A focus on food groups is beneficial because it is the manner through which a government may communicate aspects of a healthy/unhealthy diet (U.S. Department of Agriculture, 2014). Additionally, fruit and vegetable consumption appears to be a proxy for an overall healthy diet, and an increased intake of full-fat dairy appears to be a proxy for an individual's total fat consumption, and is associated with an overall unhealthy diet (Akbaraly, Brunner, Ferrie, Marmot, & Kivimaki, 2009; Epstein et al., 2001; Rolls et al., 2004; Sharma et al., 2004). Moreover, within field research, brief and targeted measurements that are linked to treatment goals may be used in a manner that both minimizes burden to participants and maximizes their relevance (Kristal, Beresford, & Lazovich, 1994). Of importance for intervention development, though, is whether changes in mood can increase the intake of servings from food groups considered to be healthy (i.e., fruits and vegetables), and/or reduce the consumption of foods considered to have the highest fat content (i.e., full-fat dairy) (U.S. Department of Agriculture, 2014).[1] There has been minimal research addressing the psychosocial dynamics of such changes.

It is possible that physical activity's clear relationship with improved moods such as depression and anxiety (Landers & Arent, 2007) might positively affect emotional eating. Although some related research is available that (mostly indirectly) supports that relationship (Andrade et al., 2010; Annesi & Tennant, 2013; Annesi, Johnson, & Porter, 2014; Teixeira et al., 2010), this area of research is admittedly underdeveloped (Jakicic, Wing, & Winters-Hart, 2002; Mann et al., 2007). Although some research indicates that at least five sessions per week of moderate physical activity are needed to improve mood (Dunn, Trivedi, Kampert, Clark, & Chambliss, 2005), other studies suggest that only about two weekly sessions are required, with no additional benefit on

[1] Oils have the highest fat content, but are not considered a food group.

mood for greater volumes (frequency, duration, intensity) (Annesi, 2012). In fact, effect sizes for mood improvements were so large in previous physical activity and exercise studies, researchers questioned whether mood regulation training (e.g., deep breathing; progressive muscle relaxation; positive visualization) would demonstrate any additional benefit (Annesi & Tennant, 2013). This research question has not been adequately addressed. Also of interest for intervention development is determination of what mediates the mood-food choice relationship. For example, if improvements in self-regulation and/or self-efficacy are significant mediators of the relationship of mood and choices of foods, then interventions and practitioners could increase their attention there.

Especially when paired with cognitive-behavioral support methods, physical activity might serve to improve self-efficacy and self-regulation for controlled eating (Annesi et al., 2014). This could occur through a "carry-over," or generalization, of effects initiated through maintaining physical activity, to effects related to improved eating (Annesi et al., 2014; Annesi & Marti, 2011; Mata et al., 2009; Oaten & Cheng, 2006; Teixeira et al., 2010). Based on social cognitive and self-efficacy theory (Bandura, 1986, 2004), and extrapolations of those theories that relate physical activity to improved eating and weight loss through psychosocial channels (Baker & Brownell, 2000), exercise program-induced improvements in self-efficacy and self-regulation are proposed to be predictors of improved nutrition. Research also suggests that self-efficacy and self-regulation might serve to mediate the effect of improved mood on healthy eating, and improved nutrition might both reinforce, and be reinforced by, increases in self-efficacy and self-regulation (Andrade et al., 2010; Annesi et al., 2014; de Bruin et al., 2012). The most comprehensive self-report measure for self-efficacy for controlled eating is multidimensional (Clark, Abrams, Niaura, Eaton, & Rossi, 1991), which might allow researchers to determine especially important influences on eating such as feelings of ability to overcome social pressures to overeat and high availability of unhealthy foods.

Research questions and hypotheses

Thus, within this field-based study, our hypotheses and research questions addressed five areas of interest for intervention development: (a) comparative effects of theory-based behavioral treatments on changes in mood, intake of fruits/vegetables, intake of fats, physical activity, self-regulation for eating, self-efficacy for controlling eating, and weight, (b) identification of the most salient predictors of weight change, (c) the relationship between mood change and consumption of specific food types, (d) possible mediators of the mood change-food intake change relationship, and (e) the relationship of physical activity volume with mood change. Specific hypotheses and research questions are as follows:

1. The cognitive-behavioral interventions that each emphasize physical activity first would be associated with significant improvements in mood, intake of fruits/vegetables, intake of fats, physical activity, self-regulation for eating, self-efficacy for managed eating, and weight over 6 months. It was left as a research question whether mood change would be greater in the group with mood regulation training added.
2. Increase in fruit/vegetable intake and physical activity, and reduction in fat intake, would each significantly contribute to the prediction of weight loss.
3. Intervention-induced reductions in negative mood would be significantly associated with increased fruit/vegetable intake and reduced fat consumption.
4. It was left as research questions, without hypotheses, whether changes in self-efficacy and/or self-regulation would significantly mediate relationships between mood change and changes in consumption of types of foods. Because of its additional value for intervention development, the reciprocity of relationships between changes in consumption of type of food and self-efficacy and/or self-regulation (if demonstrated to be a significant mediator) also would be assessed.
5. Volume of physical activity equivalent to two moderate sessions per week would be associated with a significant reduction in negative mood, with no significant additional benefit for greater volumes.

We recruited individuals with severe obesity because they have high levels of health risks and might greatly benefit from innovative intervention techniques. Because of potential benefits for widespread applicability of findings, a community-based field setting (i.e., the YMCA) was chosen as the location for this research (Green, Sim, & Breiner, 2013).

METHOD

Participants

Various print and Internet media were used to obtain adult volunteers for research on physical activity and nutrition to be conducted at local YMCAs in the southeast U.S. There was no cost incurred for, or compensation given to, participants. Inclusion criteria were: (a) age $\geq$ 21 years, (b) BMI $\geq 35 \leq 50$ kg/m^2, and (c) self-reported exercise averaging less than 20 min/week over the last year. Exclusion criteria included: (a) current participation in a medical or commercial weight-loss program, (b) pregnant or planning to become pregnant soon, and (c) presently prescribed medication for a mood disorder. Written documentation of adequate health to participate was required from a physician. Institutional review board approval was received. Each participant signed an approved informed consent form at the time of enrolment. A total of 220 adults were recruited. Of those, 200 were eligible for participation. Through use of computer-generated random numbers, simple randomization was used to assign individuals to one of the two intervention groups. Sixteen (9%) dropped out prior to the start of the study due to reported illnesses, problems with transportation, and an inability of research staff to make phone or email contact. Independent *t* tests and χ^2 tests of association indicated no significant differences in age (overall M = 44.7 years, SD = 9.6), BMI (overall M = 40.5 kg/m^2, SD = 4.9), sex (overall 77% women), or race/ethnicity (overall 53% White, 42% African American, and 5% of other racial/ethnic groups) among the two groups of cognitive-behavioral training only (n = 92) and cognitive-behavioral training + mood regulation training (n = 92). Based on self-reported household income, nearly all participants were lower-middle and middle class (Elwell, 2014).

Measures

Mood

The Total Mood Disturbance scale of the Profile of Mood States Short Form (McNair & Heuchert, 2005) measured negative mood. Participants responded to feelings over the past week via one- to three-word items (e.g., anxious, sad) ranging on its 5-point scale from 0 (*not at all*) to 4 (*extremely*). Five items within each of the subscales of tension, depression, fatigue, confusion, and anger were first summed. The score from the vigor subscale was then subtracted. Thus, scores of the 30 total items could be either negative or positive. Internal consistency results ranged from Cronbach's α = .84 - .95. Test-retest reliability scores over three weeks averaged .69 (McNair & Heuchert, 2005). For the present sample, internal consistency averaged Cronbach's α = .82. Possible scores ranged from -20 - 100, with a lower score indicating less negative mood.

Self-efficacy

The Weight Efficacy Lifestyle Scale (Clark et al., 1991) measured self-efficacy for controlling eating. It incorporates items from the five hypothesized factors of negative emotions (e.g., "I can resist eating when I am anxious"), availability (e.g., "I can resist eating when there are many different kinds of foods available"), physical discomfort (e.g., "I can resist eating when I am uncomfortable"), positive activities (e.g., "I can resist eating when I am watching TV"), and social pressure (e.g., "I can resist eating even when others are pressuring me to eat"). Responses to the scale's 20 items ranged from 0 (*not confident*) to 9 (*very confident*) on its 10-point scale, and were summed. Internal consistency ranged from Cronbach's α = .70 - .90 (Clark et al., 1991). For the present sample, internal consistency was Cronbach's α = .82. Possible scores ranged from 0-180, with a higher score indicating greater self-efficacy to control eating. In addition to the scale being unidimensional by summing all items, it could also be treated as multidimensional by addressing the four items of each of its five factors as subscales (Clark et al., 1991). In that case, each subscale score ranged from 0-36.

Self-regulation

A recently validated and published scale (Saelens et al., 2000) — that was modified to address the self-regulatory skills incorporated into the present study's treatments (e.g., "I make formal agreements with myself regarding my eating") — was used to measure self-regulation for eating. It had 10 items with responses ranging from 1 (*never*) to 5 (*often*) on its 5-point scale, that were summed. Previous research found that the scale had an internal consistency of Cronbach's α = .81, and test-retest reliability over two weeks was .74 (Annesi & Marti, 2011). For the present sample, internal consistency was Cronbach's α = .80. Possible scores ranged from 10 - 50, with a higher score indicating greater use of self-regulation for eating.

Food intake

To minimize the burden and inaccuracies associated with completion of multiple surveys at a single time (Kristal, et al., 1994), and to maximize applicability for possible future use within practice settings, single item statements were used to assess consumption of fruits, vegetables, and fats (fats via assessment of full-fat dairy [i.e., not labeled as "reduced fat," "light," "diet," or a similar descriptor]). Research suggests that, in the present context, single-item scales may be fully appropriate (Cummings, Dunham, Gardner, & Pierce, 1998). Instructions asked respondents to answer based on number of servings consumed within "a typical day over the past week." Items were based on examples and serving sizes of fruits (e.g., apple, banana, peach [1 small fresh or 118 mL canned], raisins, dates [.59 mL], 100% fruit juice [118 mL]), vegetables (e.g., broccoli, carrots, tomatoes, green beans [118 mL], raw spinach [236 mL]), and full-fat dairy products (e.g., ice cream, milk shake, yogurt [236 mL], Mozzarella cheese, cheddar cheese, Swiss cheese [57 g]), that corresponded to both the U.S. Department of Agriculture's (2014) Food Plate and their former Food Guide Pyramid. Instructions about (a) portion sizes, (b) how to score "combination foods" (e.g., a "banana split" counted for servings of both fruit and full-fat dairy), (c) what constitutes full fat, and (d) which foods to omit counting (e.g., French fried potatoes were omitted as a vegetable) were provided by the survey administrator as well being included on the written survey. In addition to the present items being validated against comprehensive food frequency questionnaires (Sharma et al., 2004), pilot research indicated strong correlations of item scores (*r*s ~ .70 - .85) with corresponding scales on the full-length Block Food Frequency Questionnaire (Block et al., 1986; Mares-Perlman, 1993). Additionally, responses from the corresponding item were strongly associated (.71) with scores on the validated Dobson Short Fat Questionnaire (Dobson et al., 1993). The Dobson Short Fat Questionnaire and Block Food Frequency Questionnaire account for total fat intake from a variety of foods (meats, seafood) and their preparation methods (e.g., frying, applying butter, with mayonnaise). Test-retest reliabilities over three weeks were .77 - .83 for women, and .80 - .84 for men. Responses to the fruit and vegetable items were summed for this research. Based on the predictive validity noted above, the terms "fruits/vegetables" and "fat" are subsequently used within this report.

Physical activity

The Godin-Shephard Leisure-Time Physical Activity Questionnaire (Godin, 2011) measured volume of physical activity. Its scores represent metabolic equivalent of tasks (METs) per week, or the energy cost based on physical activity completed in a week. One MET approximates the use of 3.5 ml of O_2/kg/min (Jetté, Sidney, & Blumchen, 1990). The Godin-Shephard Questionnaire calls for participants' entry of number of sessions of strenuous (approximately 9 METs, such as running), moderate (approximately 5 METs, such as fast walking), and light (approximately 3 METs, such as easy walking) physical activities undertaken for "more than 15 minutes" in the previous week. These scores were summed. Test-retest reliability over two weeks was .74 (Godin & Shephard, 1985). The Godin-Shephard Questionnaire's validity was supported through strong correlations with both accelerometer (an objective recorder of physical activity) and peak volume of oxygen uptake (a standard treadmill test of cardiorespiratory fitness) measurements (Jacobs, Ainsworth, Hartman, & Leon, 1993; Miller, Freedson, & Kline, 1994).

Procedure

All participants attended a group orientation specific to the intervention that they were assigned: cognitive-behavioral training only, or cognitive-behavioral training + mood regulation training. Within one week of orientation, participants reported to a local YMCA and obtained access to that facility at no cost to them for the length of the study.

The facility included an exercise area with apparatus such as treadmills, stationary bicycles, and walking/running tracks, along with meeting rooms where parts of the intervention program took place.

Group assignments

Both groups received the identical physical activity support component. In the cognitive-behavioral + mood regulation training group, although the content of the nutrition component was nearly identical to the cognitive-behavioral training group, instruction in mood regulation methods was added without lengthening the overall duration of the sessions (which might have biased results because of increased treatment time).

Physical activity support component (both groups)

The physical activity support component consisted of a protocol of six, 45-min meetings approximately monthly over 6 months (i.e., The Coach Approach). The Coach Approach protocol was selected because of its consistent association with maintenance of exercise in novice exercisers and unfit individuals (Annesi & Unruh, 2007; Annesi, Unruh, Marti, Gorjala, & Tennant, 2011). The one-on-one sessions included an orientation to available exercise apparatus and the development and revision of personal physical activity plans based on each participant's tolerance and preference. Information on the recommended minimum volume of weekly exercise of 150 min of light-moderate intensity or 75 min of moderate-strenuous intensity (Garber et al., 2011) was provided. However, it was also communicated to participants by the wellness specialists that *any* amount of physical activity could be productive, especially when starting out. Given that all participants had either severe or morbid obesity and were previously physically inactive, walking was the most common physical activity. The cognitive-behavioral methods used to support the participants' exercise behaviors were based on tenets of social cognitive and self-efficacy theory (Bandura, 1986, 2004), with an emphasis on self-regulation and self-efficacy related to completing regular physical activity. During the sessions, a wellness specialist helped set long-term goals, and broke each long-term goal down into process-oriented short-term goals (e.g., increase weekly walking from 40 min to 80 min within 1 month). They also addressed and regularly reviewed with the participant the behavioral skills of stimulus control, behavioral contracting, setting graded tasks, and self-monitoring (see Michie et al., [2011], for concise explanations of the behavioral skills/techniques utilized within the treatment components in this research). A computer program (FitLinxx, Shelton, CT) supported the administration of the protocol, allowed each participant to track his/her goal progress, and allowed viewing of physical activity progress through graphs.

Nutrition support component (both groups)

The nutrition component had six, 60-min meetings every 2 weeks starting 2 months after initiating physical activity. They were administered in groups of 10 to 15 participants. Wellness specialists provided information on both healthy eating practices and cognitive-behavioral methods to support those behaviors. Information on healthy eating was supported by a manual used by both the instructors and participants (Kaiser Permanente Health Education Services, 2009). It included: (a) understanding fats, proteins, and carbohydrates, (b) stocking healthy foods at home, (c) healthy recipes and cooking methods, and (d) healthy snacking. Cognitive-behavioral methods for improved nutrition were designed for this study to address self-regulatory skills, and were similar to those of the physical activity support component. They included: (a) establishing caloric-intake goals, (b) recording foods consumed and the associated calories, (c) understanding and addressing prompts and cues to unhealthy eating, and (d) behavioral contracting.

Mood regulation training (cognitive-behavioral + mood regulation group only)

The mood regulation training included only in the cognitive-behavioral + mood regulation group consisted of: (a) negative thought identification, thought stopping, and reframing self-talk, (b) deep breathing exercises, (c) abbreviated progressive relaxation, and (d) attention control. It was administered during the last 10-15 min of the nutrition component sessions.

Wellness specialists with YMCA and other national certifications along with specialized training in the study's protocols administered the intervention components. To assess protocol fidelity, staff observed approximately 12% of the sessions. The few minor inconsistencies with administration of the required methods were quickly corrected. Staff not otherwise involved in the research administered the five surveys and measured body weight in a private area at baseline and at the end of Month 6.

Data analysis strategy

An intention-to-treat format was used where the expectation-maximization algorithm (Schafer & Graham, 2002) was used to impute data for the 14% of missing scores that were all at study end. Statistical significance was set at $\alpha = .05$ (two-tailed). The Bonferroni adjustment for multiple tests was applied where appropriate. Based on a regression analysis with two predictors and a small-moderate effect size ($f^2 = .06$) that was anticipated from pilot research, a minimum of 162 participants was required at the statistical power of .80 ($\alpha = .05$) (Cohen, Cohen, West, & Aiken, 2003). Based on previous suggestions (Glymour, Weuve, Berkman, Kawachi, & Robins, 2005) and related research (Annesi & Porter, 2013; Teixeira et al., 2010), changes were calculated as the difference between scores at baseline and Month 6, unadjusted for their baseline values. Effect sizes were expressed as either Cohen's *d* ($[M_{\text{Month 6}} - M_{\text{baseline}}]/SD_{\text{baseline}}$) or partial eta-squared (η^2_p) where .20, .50, and .80; and .01, .06, and .14 represent small, moderate, and large effects, respectively (Cohen, 1992). Because participants' sex was significantly related to scores on psychosocial variables in preliminary testing, it was controlled for in the analyses.

Mixed-model repeated measures ANOVAs (Time x Group) were first computed to assess whether changes over 6 months in mood, intake of fruits/vegetables, intake of fats, physical activity, self-regulation for eating, and self-efficacy for controlling eating were significant, and whether the identified changes significantly differed by group (cognitive-behavioral only vs. cognitive-behavioral + mood regulation).

Next, the effect of group assignment on weight loss was assessed. After aggregating data, the prediction of weight loss by changes from baseline-Month 6 in physical activity and food types was analyzed through multiple regression. Bivariate relationships between changes in mood, self-regulation for eating, self-efficacy for controlling eating, physical activity, and intake of fruits/vegetables and fats were also calculated.

Based on the available theory and research, the current study's research questions, and identification of a bivariate relationship between changes in mood and fruit/vegetable intake that was statistically significant, mediation models (diagramed in Figure 1) were established. A bias-corrected bootstrapping procedure (Preacher & Hayes, 2008) incorporating 20,000 re-samples was used. Specifically, mediation of the relationships between change in mood and change in intake of fruits/vegetables by change scores on self-efficacy and self-regulation was tested. If significant mediation was found, then a reciprocal effects analysis (Palmeira et al., 2009) was employed that assessed the presence/non-presence of a bi-directional relationship between the equation's outcome and mediator variables (that emanated from the predictor variable that was mood change). This was carried out by reversing the outcome and mediator variables in a complementary mediation equation. If mediation in the paired equations were both significant then, by definition, a reciprocal relationship was identified (Palmeira et al., 2009).

Finally, in a separate analysis, data on mood change were grouped based on participants' estimated volume of physical activity completed over the 6-month study. It included groups of participants who completed one exercise session/week (5-9 METs/week), two sessions/week (10-14 METs/week), and so forth through five or more sessions/week ($\geq$ 25 METs/week). ANOVA was used to contrast changes in mood by these physical activity groupings. A stepwise multiple regression analysis was then fit to assess whether the inclusion of mood regulation methods (i.e., participation

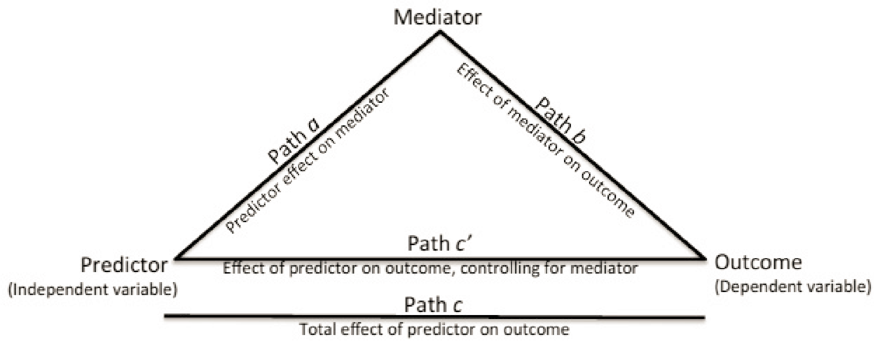

Figure 1. Relationships incorporated in the mediation analyses.

in the cognitive-behavioral + mood regulation group) was significantly related to mood improvement beyond that of increase in physical activity.

RESULTS

Mood and food intake

No significant group differences were found in mood, intake of fruits/vegetables, intake of fats, physical activity, self-regulation for eating, and self-efficacy for controlling eating at baseline. Effects of time were significant for mood, $F(1, 181) = 26.36, p < .001, \eta^2_p = .127$; fruit/vegetable intake, $F(1, 181) = 11.20, p = .001, \eta^2_p = .058$; fat intake, $F(1, 181) = 4.72, p = .031, \eta^2_p = .025$; physical activity, $F(1, 181) = 160.35, p < .001, \eta^2_p = .470$; self-regulation, $F(1, 181) = 85.68, p < .001, \eta^2_p = .321$; and self-efficacy, $F(1, 181) = 15.88, p < .001, \eta^2_p = .081$. There was no significant time x group interaction (*p*s = .655, .381, .134, .259, .557, and .800, respectively). With the exception of fat intake for the cognitive-behavioral only group, significant within-group improvements were found over 6 months in each of the aforementioned variables (Table 1).

Weight change

No significant group difference was found in weight at baseline. Effects of time were significant, $F(1, 181) = 74.37, p < .001, \eta^2_p = .291$. There was no significant time x group interaction, $F(1, 181) = 0.196, p = .658, \eta^2_p = .001$. Significant within-group

Table 1. Within-group changes in study variables over 6 months

Measure	Baseline		Month 6		*t*	*p*	[95% CI]	Change		*d*
	M	*SD*	*M*	*SD*				*M*	*SD*	
Negative mood										
Cog-behavioral only	19.92	15.49	4.35	12.91	-9.07	<.001	[-18.99, -12.17]	-15.57	16.47	1.01
Cog-behavioral+mood reg	22.16	16.35	7.41	15.73	-8.51	<.001	[-18.19, -11.31]	-14.75	16.62	.90
Overall sample	21.04	15.92	5.88	14.43	-12.46	<.001	[-17.56, -12.76]	-15.16	16.51	.95
Fruit and vegetable intake/day										
Cog-behavioral only	4.60	2.06	5.47	1.99	4.92	<.001	[0.52, 1.23]	0.87	1.71	.42
Cog-behavioral+mood reg	4.42	1.77	5.54	1.95	6.17	<.001	[0.76, 1.47]	1.12	1.73	.63
Overall sample	4.51	1.92	5.51	1.97	7.85	<.001	[0.74, 1.24]	1.00	1.72	.52
Fat intake/day										
Cog-behavioral only	2.02	1.15	1.84	0.94	-1.42	.160	[-0.42, 0.17]	-0.18	1.18	.16
Cog-behavioral+mood reg	1.79	1.11	1.37	0.93	-3.60	.001	[-0.65, -0.19]	-0.42	1.12	.38
Overall sample	1.90	1.13	1.61	0.96	-3.46	.001	[-0.46, -0.13]	-0.29	1.15	.26
Physical activity										
Cog-behavioral only	9.09	9.11	34.79	17.57	16.08	<.001	[22.53, 28.88]	25.70	15.33	2.82
Cog-behavioral+mood reg	8.88	8.34	27.77	11.53	21.95	<.001	[17.18, 20.60]	18.89	8.25	2.26
Overall sample	8.98	8.71	31.28	15.24	23.73	<.001	[20.44, 24.15]	22.29	12.75	2.56
Self-regulation for eating										
Cog-behavioral only	20.77	5.68	28.15	6.19	11.27	<.001	[6.08, 8.68]	7.38	6.28	1.29
Cog-behavioral+mood reg	22.30	5.94	30.04	5.49	12.30	<.001	[6.49, 8.99]	7.74	6.03	1.30
Overall sample	21.54	5.85	29.10	5.91	16.68	<.001	[6.67, 8.45]	7.56	6.15	1.29
Self-efficacy for eating (total)										
Cog-behavioral only	100.49	35.76	130.95	28.34	8.83	<.001	[23.61, 37.32]	30.46	33.11	.85
Cog-behavioral+mood reg	94.13	33.89	124.62	33.23	8.19	<.001	[23.10, 30.49]	30.49	35.70	.90
Overall sample	97.31	34.89	127.79	30.96	12.04	<.001	[25.48, 35.47]	30.48	34.33	.87
Negative emotions (subscale)										
Cog-behavioral only	18.63	10.27	25.43	7.56	6.77	<.001	[4.81, 8.80]	6.80	9.65	.66
Cog-behavioral+mood reg	15.14	9.27	23.15	9.23	8.76	<.001	[6.19, 9.83]	8.01	8.77	.86
Overall sample	16.89	9.91	24.29	8.49	10.90	<.001	[6.07, 8.75]	7.40	9.22	.75
Availability (subscale)										
Cog-behavioral only	14.48	8.53	22.42	8.11	8.87	<.001	[6.16, 9.72]	7.94	8.59	.93
Cog-behavioral+mood reg	13.80	7.35	21.08	8.20	7.20	<.001	[5.27, 9.28]	7.28	9.68	.99
Overall sample	14.14	7.95	21.74	8.16	11.30	<.001	[6.28, 8.93]	7.60	9.13	.96

(continued)

Table 1. (continued)

Measure	Baseline		Month 6		*t*	*p*	[95% CI]	Change		*d*
	M	*SD*	*M*	*SD*				*M*	*SD*	
Social pressure (subscale)										
Cog-behavioral only	19.83	10.54	26.05	7.51	6.68	<.001	[4.38, 8.08]	6.22	8.94	.59
Cog-behavioral+mood reg	20.28	10.21	26.45	8.00	6.07	<.001	[4.15, 8.18]	6.17	9.74	.60
Overall sample	20.05	10.35	26.25	7.74	9.01	<.001	[4.84, 7.55]	6.20	9.33	.60
Physical discomfort (subscale)										
Cog-behavioral only	24.80	8.66	29.20	6.10	5.20	<.001	[2.72, 6.07]	4.40	8.09	.51
Cog-behavioral+mood reg	23.83	8.59	27.26	7.88	4.27	<.001	[1.84, 3.43]	3.43	7.72	.40
Overall sample	24.32	8.61	28.23	7.09	6.72	<.001	[2.76, 5.06]	3.91	7.90	.45
Positive activities (subscale)										
Cog-behavioral only	22.75	7.28	27.85	6.29	6.54	<.001	[3.55, 6.65]	5.10	7.47	.70
Cog-behavioral+mood reg	21.08	7.73	26.68	6.63	6.64	<.001	[3.93, 7.29]	5.60	8.10	.72
Overall sample	21.91	7.54	27.27	6.47	9.34	<.001	[4.22, 6.48]	5.36	7.78	.71
Weight (kg)										
Cog-behavioral only	118.37	15.94	113.83	14.21	8.60	<.001	[-5.59,-3.49]	-4.54	5.01	.28
Cog-behavioral+mood reg	111.57	15.23	107.00	14.24	8.59	<.001	[-5.63, -3.52]	4.58	5.11	.30
Overall sample	114.98	15.92	110.41	14.59	12.19	<.001	[-5.30, -3.82]	-4.56	5.07	.29

Note: Cognitive-behavioral training only group n = 92 (df = 91). Cognitive-behavioral training + mood regulation training group n = 92 (df = 91). Overall sample N = 184 (df = 183). 95% CI = 95% confidence interval. d denotes Cohen's d.

improvements were found over 6 months. Mean weight change per group is given in Table 1. There was considerable variability in weight change, by participant (range = -20.80 kg to 7.10 kg; M = -4.56 kg, SD = 5.07). Findings indicated that 80% of participants lost some weight, and 58% lost at least 3% of their original body weight, which is the amount considered the minimum required for a reduction in health risks (Donnelly et al., 2009).

Using aggregated data, a multiple regression analysis, with simultaneous entry of changes in physical activity and the two food types as predictors of weight change, indicated that increases in physical activity volume, $\beta = -.23$, $SE = .03$, $p = .002$, and consumption of fruits/vegetables, $\beta = -.17$, $SE = .21$, $p = .018$, each independently contributed to the overall explained variance in weight loss, $R^2 = .32$, $SE = 4.85$, $p < .001$. Reduction in fat intake did not reach statistical significance in the prediction of weight loss after controlling for the other predictors in the equation, $\beta = .12$, $SE = .32$, $p = .095$.

Mediators of the mood-fruit/vegetable intake relationship

Intercorrelations of scores of mood, self-regulation, and self-efficacy indicated minimal shared variance (r^2s $\leq$ .15) (see Table 2). Thus, they were considered sufficiently independent for further analyses. Reduction in negative mood was significantly related to increase in fruits/vegetables, β = -.24, SE = .01, p = .001, but not fat, β = .06, SE = .01, p = .435.

Table 2. Intercorrelations of changes in study variables (N = 184)

	1	2	3	4	5	6	7
1. ΔMood	...						
2. ΔSelf-efficacy	-.34†	...					
3. ΔSelf-regulation	-.34†	.39†	...				
4. ΔFruits/Vegetables	-.24†	.28†	.20†	...			
5. ΔFats	.06	-.07	-.07	-.13	...		
6. ΔPhysical activity	-.19†	.14	.21†	.10	.17*	...	
7. ΔWeight	.13	-.14	-.25†	-.21†	.11	-.22†	...

Note: The Delta symbol (Δ) denotes change from baseline to Month 6.

*p < .05. †p < .01.

In the first multiple mediation analysis, change in self-efficacy, but not change in self-regulation, significantly mediated the mood-fruit/vegetable intake relationship (Table 3, Analysis I). Because it was found that change in self-efficacy, alone, was a significant mediator of the relationship between changes in mood and fruit/vegetable intake — and in its complementary equation, change in fruit/vegetable intake was a significant mediator of the relationship between change in negative mood and change in fruit/vegetable intake (Table 3, Analysis II) — it was determined that a reciprocal relationship between changes in self-efficacy and fruit/vegetable consumption change was identified.

In an extension of the above Analysis I, the putative components of self-efficacy for controlling eating (i.e., Weight Efficacy Lifestyle Scale subscales; Clark et al., 1991) were simultaneous entered as mediators of the mood-fruit/vegetable consumption relationship. If one or more were found to be significant mediators, after controlling for the others, this could direct the refinement of intervention foci to especially salient dimensions of self-efficacy. However, none of the five subscales was found to be an independently significant mediator (Table 3, Analysis III).

Table 3. Results from multiple mediation and reciprocal effects analyses (N = 184)

Predictor	Mediator	Outcome	Path *a*	Path *b*	Path *c*	Path *c*'	Indirect effect (Path *a* × Path *b*)	R^2
			β(*SE*) *p*	β(*SE*) *p*	β(*SE*) *p*	β(*SE*) *p*	β(*SE*) [95% CI]	*p*
Analysis I								
ΔMood	ΔSelf-efficacy	ΔFruits/ Vegetables	-.68(.14) <.001	.01(.004) .013	-.03(.01) .001	-.02(.01) .049	-.01(.004) [-.015, -.002]	
ΔMood	ΔSelf-regulation	ΔFruits/ Vegetables	-.13(.03) <.001	.02(.02) .418	-.03(.01) .001	-.02(.01) .049	-.01(.004) [-.009, .003]	
Model								.11 <.001
Analysis II								
ΔMood	ΔSelf-efficacy	ΔFruits/ Vegetables	-.68(.14) <.001	.01(.004) .003	-.03(.01) .001	-.02(.01) .026	-.01(.004) [-.017, -.002]	.11 <.001
ΔMood	ΔFruits/ Vegetables	ΔSelf-efficacy	-.03(.01) .001	4.23(1.40) .003	-.68(.14) <.001	-.58(.15) <.001	-.11(.05) [-.218, -.035]	.17 <.001
Analysis III								
ΔMood	ΔNegative emotion	ΔFruits/ Vegetables	-.15(04) <.001	.02(.02) .388	-.03(.01) .001	-.02(.01) .023	-.002(.003) [-.009, .003]	
ΔMood	ΔAvailability	ΔFruits/ Vegetables	-.14(04) .001	.04(.02) .078	-.03(.01) .001	-.02(.01) .023	-.01(.004) [-.015, .0002]	
ΔMood	ΔSocial pressure	ΔFruits/ Vegetables	-.16(.04) <.001	.01(.02) .655	-.03(.01) .001	-.02(.01) .023	-.001(.003) [-.008, .005]	
ΔMood	ΔPhysical discomfort	ΔFruits/ Vegetables	-.12(.03) .001	-.01(.02) .623	-.03(.01) .001	-.02(.01) .023	.001(.002) [-.003, .007]	
ΔMood	ΔPositive activities	ΔFruits/ Vegetables	-.12(.03) .001	.00(.02) .993	-.03(.01) .001	-.02(.01) .023	.000(.003) [-.005, .007]	
Model								.12 .002

Note: Analyses are based on a bootstrapping procedure for multiple mediation (Preacher & Hayes, 2008) incorporating 20,000 resamples and controlling for participants' sex.
Δ = change from baseline to Month 6. 95% CI = 95% confidence interval.
Path *a* = predictor→mediator; Path *b* = mediator→outcome; Path *c* = predictor→outcome; Path *c*' = predictor→outcome, controlling for the mediator.

Physical activity volume and mood change

Baseline scores on negative mood did not significantly differ by the physical activity-based grouping, $F(4, 179) = 0.74$, $p = .567$, $\eta^2_p = .016$. All significantly increased physical activity over 6 months (ps < .001), with participants completing one exercise session/week ($n = 25$) averaging 7.36 METs/week ($SD = 1.94$), two sessions/week ($n = 37$) averaging 12.30 METs/week ($SD = 1.24$), three sessions/week ($n = 41$) averaging 16.95 METs/week ($SD = 1.28$), four sessions/week ($n = 36$) averaging 22.65 METs/week ($SD = 1.46$), and five or more sessions/week ($n = 45$) averaging 34.55 METs/week ($SD = 9.67$). The difference in mood change was significant, by physical activity grouping, $F(4, 179) = 2.59$, $p = .038$, $\eta^2_p = .055$. Post hoc follow-up testing using the Fisher's Least Significant Difference (LSD) test indicated that the mood improvement in participants completing one exercise session/week ($M = -6.76$, $SD = 16.24$) was significantly less than in those completing two ($M = -13.00$, $SD = 16.21$), three ($M = -18.51$, $SD = 17.31$), four ($M = -17.83$, $SD = 16.67$), and five or more ($M = -15.16$, $SD = 16.51$) sessions/week. No significant difference between participants completing two through five or more sessions/week were found. Follow-up dependent t tests, with the Bonferroni adjustment revising the significant p-value to < .01, indicated that, with the exception of participants completing one exercise session/week, $t(24) = 2.05$, $p = .052$, $d = .41$, within-group reductions in negative mood for two through five or more sessions/week were significant, $t(36) = 4.88$, $d = .77$; $t(40) = 6.85$, $d = 1.15$; $t(35) = 6.42$, $d = 1.00$; and $t(44) = 7.45$, $d = 1.18$; respectively, ps < .001.

Increase in physical activity was, overall, significantly related to reduced negative mood, $R^2 = -.19$, $p = .008$; however, the addition of mood regulation methods (within the cognitive-behavioral + mood regulation group) did not significantly increase the explained variance, $\Delta R^2 = -.002$, $p = .702$; with the overall $R^2 = -.20$, $p = .029$.

DISCUSSION

Findings are useful for enhancing the theoretical underpinnings of behavioral weight-loss interventions, and for developing cost-effective and relevant behavioral treatments for controlling eating and weight in adults with obesity. Consistent with previous research (Konttinen et al., 2010; Macht, 2008), and in partial support of our hypotheses, a treatment-associated improvement in mood over 6 months was significantly related to increased fruit/vegetable intake. However, the association between improved mood and reduced fat intake did not reach statistical significance. Adding mood regulation training to cognitive-behavioral methods and physical activity did not further improve the large effects observed on negative mood without such an addition. In addition to physical activity, increased fruit/vegetable intake was a significant predictor of weight loss, while the relationship of reduction in the consumption in fat with weight loss did not reach statistical significance.

Change in self-efficacy for controlling eating was a significant mediator of the mood change-fruit/vegetable intake change relationship. Consistent with both social cognitive theory (Bandura, 1986) and self-efficacy theory (Bandura, 1997), feelings of increased ability and competence for controlling eating also demonstrated a bi-directional, reciprocal relationship with improvement in one's diet. Findings also supported recent research on relationships between physical activity, mood, self-efficacy, and food intake (Napolitano & Hayes, 2011). Taken together, the present results suggest that future behavioral interventions for obesity include nurturing self-efficacy by demonstrating short-term dietary progress made by individuals. Also important will be facilitating self-regulatory skills such that individuals feel empowered to offset or counter unhealthy food-related behaviors and social pressures to overeat, consumption of unhealthy "fast foods," and cues for inappropriate eating (e.g., boredom, time pressure, watching television, portion sizes that are extremely large). Although an inability to counter barriers could undermine self-efficacy, no particular dimension of self-efficacy (Clark et al., 1991) was presently identified as more important than others in terms of its mediating effect of the mood change-fruit/vegetable intake change relationship.

Implications of physical activity

The study's treatments consisted of physical activity supported by cognitive-behavioral methods that were introduced two months prior to the nutritional components. Especially when interventions support "carry over" effects, behavioral skills and changes acquired or nurtured through physical activity could generalize to skills required for better food selections and a better diet (Annesi et al., 2014; Annesi & Marti, 2011; Mata et al., 2009; Oaten & Cheng, 2006, Teixeira et al., 2010). Moreover, physical activity has demonstrated the potential of improving moods and reducing emotional eating (Annesi et al., 2014; Annesi & Marti, 2011; Annesi & Tennant, 2013; Baker & Brownell, 2000; Landers & Arent, 2007).

Within this research, only two sessions per week of physical activity was required to significantly reduce negative mood, with no significant difference in mood improvement with greater volumes. This finding is important because less than 5% of U.S. adults complete the five sessions of exercise per week that are considered the minimum needed for health benefits (Garber et al., 2011; Troiano et al., 2009), and also proposed to be the minimum volume required for improved mood (Dunn et al., 2005). Notably, greater (and thus more challenging) volumes of physical activity are, in themselves, associated with greater exercise drop out (Trost, Owen, Bauman, Sallis, & Brown, 2002). Because a dose-response relationship (more physical activity - improved mood change) does not seem evident (Annesi, 2012; Landers & Arent, 2007), research and theory (Baker & Brownell, 2000; Bandura, 1986) suggest a behavioral, rather than biochemical, explanation of their association (e.g., maintained physical activity fosters feelings of self-efficacy and better overall feelings of the self which, in turn, improves mood; see Landers & Arent, 2007; Morgan, 1997a). Thus, if moderate volumes of physical activity are supported by basic cognitive-behavioral interventions to support adherence, both mood and eating habits might improve and be better sustained over the long-term.

Limitations

Although useful findings from the present findings appear evident, limitations of this research should also be acknowledged. Inclusion of a control group will be essential for establishing confidence in the present findings, and helping to reduce social support and/or experimenter-expectancy effects (e.g., halo effect, Rosenthal effect, demand characteristics; Morgan, 1997b) that are common in field research such as this. Incorporation of a wait-list control condition would be advantageous by both strengthening results and providing a means by which to examine retention. The self-select nature of participation in this research challenged the applicability of findings to the overall population of adults with obesity. This might be partially countered in future research through recruitment of individuals who are strongly encouraged to begin weight-management programs by their physicians (rather than by relying on inherently self-motivated volunteers). Based on selected theory and previous research, a scheme was advocated within the current investigation where exercise-induced mood improvements leads to better eating, while being mediated by increased self-efficacy or self-regulation. Other schemes incorporating the same variables are also possible (e.g., improved eating leads to increased self-efficacy which then induces improved mood), and might be even more viable. Given the significant intercorrelations identified in Table 2, additional patterns of relationships among variables (emanating from appropriate theoretical underpinnings) should be tested in extensions of this research, and contrasted with the present findings.

Even using the proposed paradigm, specifically *what* mechanisms were associated with what observed changes remain unclear. The interventions had several educational and cognitive-behavioral components, but only the effects of mood-regulation strategies were specifically assessed. Additional research is needed to refine the inclusion of specific intervention components, based on their unique effects, before scalable program models should be proposed (Baranowski, Lin, Wetter, Resnicow, & Hearn, 1997). Additionally, more comprehensive analytic methods for assessing the effect of behavioral treatments on the fluctuation of multiple variables over time, including the use of latent growth modeling (Fitzmaurice, Laird, & Ware, 2004), will be advantageous. In the present analytic format, although assessing the dynamic effects of the variables of interest over time was an advantage, administration of measures at two times increased their measurement error considerably (Nunally & Bernstein, 1994). Longitudinal studies with follow-ups are also needed to evaluate the sustainability of positive effects. We recommend replicating the study with different population groups and nationalities to assess generalizability.

Finally, although the threshold reduction in weight required for health benefits (Donnelly et al., 2009) was attained by 58% of participants, the average weight loss was only 4.6 kg. However, this was based on a conservative intention-to-treat approach that included even early dropouts in all analyses. This contrasts with many weight-loss treatment studies that included only individuals with considerable treatment compliance in their analyses. Nonetheless, refinements in intervention components will still be needed to maximize future weight-loss outcomes.

Summary

Even though limitations were present, we were able to implement an experimental intervention model in a community-based setting and realize the benefits of evaluating its effectiveness on obesity management in a practical venue (Glasgow & Emmons, 2007; Green et al., 2013). Findings suggest that cognitive-behavioral treatment methods that first emphasize increased physical activity can improve mood and eating behaviors. Facilitation of increased self-efficacy to control eating may mediate the physical activity-mood change relationship, with increased fruit and vegetable intake and improved mood reinforcing one another. Only two moderate sessions per week of physical activity appear to be required to significantly reduce negative mood for those with severe obesity who were also sedentary. Based on the current results, behavioral weight-loss theory was extended and key intervention components were suggested for more comprehensive testing. We hope that extensions of this research continue to improve our understanding of, and ability to effectively address, the dynamics of the poor health behaviors that have advanced the obesity epidemic.

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