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Self-Regulatory Skills for Controlled Eating Emanating From Newly Initiated Physical Activity

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The relationship of physical activity with weight loss may largely be due to its association with psychosocial factors. The goal of this research was to clarify such relationships using a field design lasting 24 weeks. In Study 1, change in self-regulation for controlled eating, but not energy expenditure, mediated the relationship between changes in physical activity and weight in formerly sedentary, severely obese adults (n = 174). In Study 2 (n = 148), the addition of a cognitive-behavioral nutrition treatment was associated with significantly greater improvement in self-regulation for eating. Physical activity-related self-regulation changes were related to those improvements. Changes in self-efficacy for controlled eating and mood mediated the prediction of changes in eating-related self-regulation from changes on physical activity-related self-regulation. Change in body satisfaction was not a significant mediator. Based on the findings, practical uses of physical activity to enhance self-regulatory skills for controlled eating were suggested.

Keywords: *nutrition, obesity, physical activity, self-regulation*

Introduction

The prevalence of overweight and obesity approximates two-thirds of the adult U.S. population (Flegal, Carroll, Ogden, & Curtin, 2010) and creates a severe community health problem. Outcomes of behavioral weight-management programs have been unreliable (Mann et al., 2007). When weight is reduced, old behaviors (and most lost weight) will typically return (Jeffery et al., 2000). The universal prescription for reducing an unhealthy weight is to increase physical activity (to promote energy expenditure) and eat less calorie-dense foods (to reduce energy intake). Although physical activity is, in itself, reliably related to weight loss, it has been proposed that much of its effects are due to its association with psychosocial factors such as self-regulation (Oaten & Cheng, 2006). It has also been suggested that self-regulation initially gained through increasing physical activity could "carry over" to self-regulation for controlled eating (Mata et al., 2009). Specifically tailoring the transfer of self-regulatory skills derived from a treatment supporting physical activity to self-regulation skills focused on supporting healthy eating might maximize effects (Annesi & Marti, 2011).

Changes in other psychosocial factors associated with initiating weight-management behaviors such as body satisfaction, mood, and self-efficacy to control eating may impact the transfer of physical activity-related self-regulation to eating-related self-regulation (Hagger, Wood, Stiff, &

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Chatzisarantis, 2010). Accounting for these may provide a more complete picture of the interplay of psychosocial factors associated with changes in weight-loss behaviors, and address criticisms of the lack of such data available to improve treatments (Freidman & Brownell, 1995). Thus, two studies were designed to address related research questions though the use of social cognitive theory (Bandura, 1986, 2004). In the initial of two related studies, self-regulation and energy expenditure were assessed as possible mediators of the relationship of change in physical activity with weight change. In the subsequent study, a nutrition treatment based on the findings from the initial study was tested for its association with greater improvements in self-regulation for eating. Analyses of the relationship of physical activity- and eating-related self-regulation, through mediators emanating from social cognitive theory, was also completed.

Severely obese adults were included because of an urgent need to address health behaviors in this subgroup. A practical setting, incorporating a validated exercise-support protocol used in YMCAs (i.e., The Coach Approach; Annesi, Unruh, Marti, Gorjala, & Tennant, 2011), was selected so that findings may be readily applied through health behavior change practitioners within the community. In Study 1, it was hypothesized that (a) there would be a significant inverse relationship between changes in physical activity and weight, and (b) changes in both energy expenditure and self-regulation for controlled eating would significantly mediate the relationship between changes in physical activity and weight. In Study 2, it was hypothesized that (a) the addition of a cognitive-behavioral nutrition treatment component would significantly increase self-regulation for controlled eating when contrasted with scores from Study 1, (b) an increase in physical activity-related self-regulation would be significantly related to (carry over to) an increase in self-regulation for controlled eating, and (c) treatment-related changes in body areas satisfaction, mood, and self-efficacy for controlled eating would mediate the relationship between changes in physical activity-related self-regulation and eating-related self-regulation.

Method

Participants

Local newspapers and other print media were used to solicit volunteers for "… research on exercise and nutrition instruction for weight loss" to be completed in YMCA centers in the southeast United States. Inclusion criteria were (a) age ≥ 21 years, (b) BMI $\geq 35 \leq 55$ kg/m^2, and (c) no regular self-reported exercise (< 20 min/week). Exclusion criteria were (a) enrollment in a commercial or medical weight-loss program, (b) pregnancy, and (c) taking psychotropic medications (which might affect survey responses). Documentation of adequate health to participate was required from a physician. Institutional review board approval was received. Written informed consent was provided by all participants.

There were two waves of participant enrollment that were spaced by 8 months. Participants in the first wave (Study 1, n = 174) had a mean age of 43.6 years (SD = 9.6); 21% men; 54% white, 42% African American, 4% other races/ethnicities; and 6% attrition prior to study start (due to reported problems with transportation and not returning phone calls or emails). Participants in the second wave (Study 2, n = 148) had a mean age of 42.9 years (SD = 10.0); 15% men; 47% white, 49% African American, 4% other races/ethnicities; and 7% attrition prior to study start. Based on self-reported family income, nearly all participants were in the middle class.

Measures

Self-Regulation

Self-regulation for physical activity and self-regulation for controlled eating were separately measured by adapting a validated survey (Saelens et al., 2000), so that it was consistent with the self-regulation skills used in the present treatments. Examples of the 10 items per scale for Study 1 and Study 2 were "I set physical activity goals" and "I keep a record of my eating" respectively. Responses ranged from 1 (*never*) to 5 (*often*). Internal consistencies for the versions used in this research were $\alpha = .79$ and .81, respectively; and test–retest reliability over 2 weeks was .78 and .74, respectively (Annesi & Marti, 2011).

Body Areas Satisfaction

The Body Areas Satisfaction scale of the Multidimensional Body-Self Relations Questionnaire (Cash, 1994) measured satisfaction with aspects of one's body. Responses to its items focus on specific areas of the body (e.g., lower torso [buttocks, hips, thighs, legs]; mid torso [waist, stomach]) and ranged from 0 (*very dissatisfied*) to 4 (*very satisfied*). The overall score is the mean of item responses. Internal consistency for women and men was $\alpha = .73$ and .77, respectively; and test–retest reliability over 4 weeks was .74 and .86, respectively (Cash, 1994).

Self-Efficacy for Controlled Eating

This variable was measured using the Weight Efficacy Lifestyle Scale (Clark, Abrams, Niaura, Eaton, & Rossi, 1991), which incorporated 20 items from its five factors that each started with "I can resist eating even when …" (e.g., "I am depressed or feeling down" [negative emotions], "high-calorie foods are available" [availability], "I am uncomfortable" [physical discomfort], "I am watching TV" [positive activities], and "others are pressuring me to eat" [social pressure]). They were summed for a total score. Responses ranged from 0 (*not confident*) to 9 (*very confident*). Internal consistency ranged from $\alpha = .70$ to .90 (Clark et al., 1991).

Mood

The Profile of Mood States Short Form's measure of total mood disturbance (McNair & Heuchert, 2005) was used to measure mood. It is an aggregate of its six subscales of depression (e.g., "gloomy"), tension (e.g., "anxious"), fatigue (e.g., "weary"), vigor (e.g., "energetic"), confusion (e.g., "bewildered"), and anger (e.g., "annoyed"). Responses to the 30 items of the measure ranged from 0 (*not at all*) to 4 (*extremely*) were based on the prompt, "how you have been feeling during the past week, including today." Internal consistencies ranged from $\alpha = .84$ to .95, and test–retest reliabilities at 3 weeks averaged .69 (McNair & Heuchert, 2005).

Physical Activity

Volume of physical activity was measured by the Godin-Shephard Leisure-Time Physical Activity Questionnaire (Godin, 2011). It incorporated estimates of metabolic equivalents of tasks (METs), or the physiological energy cost based on physical activity intensity (Ainsworth et al., 2000). Weekly frequencies of strenuous ("heart beats rapidly," e.g., running), moderate ("not exhausting," e.g., fast walking), and light ("minimal effort," e.g., easy walking) physical activities for more than 15 min per session were recorded and then multiplied by 9, 5, and 3 METs, respectively. Those scores were then summed. Test-retest reliability over 2 weeks was .74 (Godin & Shephard, 1985). Construct validity was indicated by significant correlations with accelerometer, peak volume of oxygen uptake, and body fat assessments (Godin & Shephard, 1985; Jacobs, Ainsworth, Hartman, & Leon, 1993; Miller, Freedson, & Kline, 1994). Energy (kcal) expenditures over the course of the study were estimated for each participant through the following formula: kcal expenditure = METs × weight (kg) × time (hours; Ainsworth et al., 2000). Weight (kg) was measured using a recently calibrated digital scale.

Procedure

Participants reported to a YMCA facility that included an exercise center with a selection of apparatus (e.g., treadmills, stationary bicycles, walking/running tracks), received a group orientation, and were provided access to that facility for the 24-week investigation. Only the nutrition components of the treatments differed between Study 1 and Study 2. Treatments were administered by YMCA certified wellness specialists with either bachelor's or master's degrees along with an additional certification from an accredited health-promotion organization (e.g., American College of Sports Medicine, American Council on Exercise). Each professional was also provided additional training in the protocol he/she administered in the studies.

Physical Activity Treatment Component

The physical activity support component consisted of a computer-supported protocol of six, 45- to 60-min (one-on-one) meetings (at study start, and Weeks 2, 4, 8, 16, and 24) (Annesi et al., 2011). These sessions also included an orientation to available apparatus (e.g., treadmills; stationary cycles). Long-term goals were identified by participants and broken down into process-oriented short-term goals with the help of the wellness specialist. Self-regulatory skills of cognitive restructuring, stimulus control, behavioral contracting, and relapse prevention were addressed at separate sessions and also regularly reviewed. Exercise modalities were based on each participant's preference. Standard exercise recommendations (i.e., 150 min/week of moderate cardiovascular activity; Garber et al., 2011) were briefly stated; however, the benefit from any increase in physical activity was also clearly indicated.

Nutrition Treatment Components

The nutrition components had six 1-hour sessions administered in a group format of 10–15 participants (Weeks 8, 10, 12, 14, 16, and 18). In Study 1, nutrition education in healthy eating practices was emphasized using a standard protocol (Kaiser Permanente Health Education Services, 2008) that included (a) understanding macronutrients and calories, (b) menu planning (c) healthy recipes, (d) appropriate snacking, and (e) stocking healthy foods at home. In Study 2, self-regulation methods to control eating, rather than nutrition education, were emphasized. The protocol included (a) establishing caloric goals based on existing weight; (b) logging foods consumed, time, and associated calories; (c) thought stopping and cognitive restructuring; (d) relapse prevention training; and (e) addressing cues to overeating.

The treatment administrators were blind to the goals of the research. Treatment fidelity was assessed by study staff who audited approximately 20% of treatment sessions. Corrective measures were taken to address the three minor violations of the protocols that were observed. Assessments were administered in a private area at baseline and Week 24 (baseline and Week 12 for self-regulation for physical activity).

Data Analysis

An intention-to-treat design was used with the expectation-maximization algorithm (Schafer & Graham, 2002) employed for imputation of data for the 13% (Study 1) and 15% (Study 2) of missing scores (all missing at study end due to participant attrition). The intention-to-treat format has the advantage of accounting for all participants who begin a study and, thus, is less biased than when only those who complete all assessments are included in the analyses. The expectation-maximization algorithm has the advantage of accounting for data from other variables to impute a score (expectation step) and then assesses whether that score is the most likely (maximization step). This process repeats until a most likely score is determined and imputed (Schafer & Graham, 2002). Statistical significance was set at α = .05 (two-tailed). To detect a small–moderate effect (f^2 = .10) at the statistical power of .80 with three predictor variables, a minimum of 112 participants (per study) was needed (Cohen & Cohen, 1983). As suggested for the present research situation, gain (change) scores were unadjusted for their baseline value (Glymour, Weuve, Berkman, Kawachi, & Robins, 2005).

For Study 1, to determine mediators of the relation of change in physical activity with weight change, energy expenditure associated with the physical activity and change in self-regulation for eating (over 24 weeks) were simultaneously entered into a mediation analysis equation. Mediation analysis assesses changes in the direct relationship between a predictor and outcome variable by accounting for additional relationships: (a) the relationship between the predictor and one or more additional variables (i.e., potential mediators; termed Path *a*), (b) the relationship between the mediator(s) and the outcome variable (termed Path *b*), and (c) how the now indirect relationship between the predictor and outcome variables (Path *c'*) is affected by accounting for Path *a* and Path *b* (Figure 1). A bias-corrected bootstrapping procedure incorporating 10,000 resamples was used because this method had the benefit of not requiring normally distributed data and allowed for the simultaneous entry of multiple mediators, which protected experimental power (Preacher & Hayes, 2008).

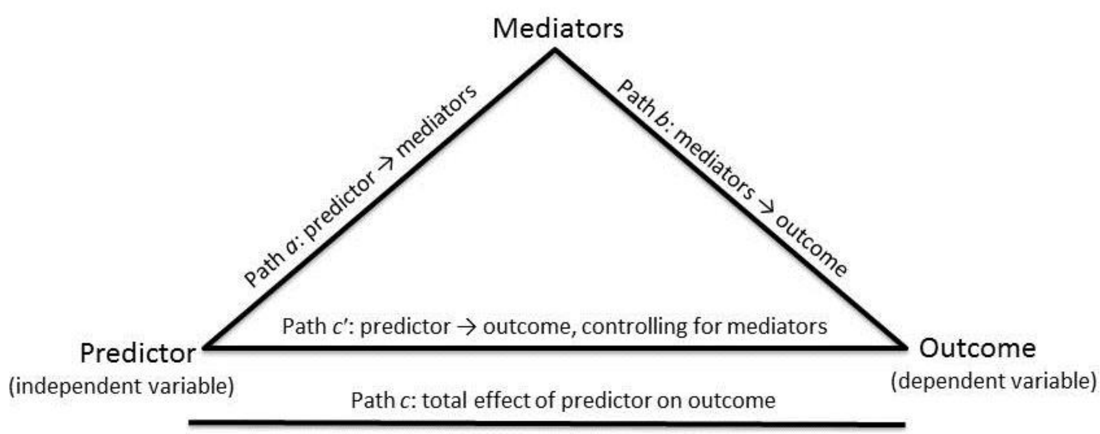

Figure 1: *Processes of Mediation Analysis*

For Study 2, a treatment was adapted based on findings from the mediation analysis in Study 1. A mixed-model repeated-measure ANOVA assessed whether score changes in self-regulation for controlled eating were significantly greater in that sample when contrasted with the sample from Study 1. A mixed-model repeated-measure ANOVA has the advantage of simultaneously assessing score changes within groups while also contrasting between-group differences in these score changes. Thus, this method of analyses retains more experimental power than when multiple tests are calculated on the same data.

For participants in Study 2, possible mediation of the transfer of self-regulation for physical activity change over the initial 12 weeks of the study to change in self-regulation for controlled eating (over 24 weeks) by body satisfaction, self-efficacy for controlled eating and mood change (also over 24 weeks) were then assessed. Although estimating temporal effects has limitations, evaluating the result of early changes in physical activity-related self-regulation (the predictor variable) on subsequent changes in eating-related self-regulation (the outcome variable) within a longitudinal design may be advantageous (Roe, 2012). Because it was of concern that the two self-regulation measures may have represented a single construct (e.g., overall, or trait, self-regulation ability), collinearity between the psychosocial measures at baseline was evaluated. Less than a strong correlation ($r < .50$; Cohen, 1992) indicated sufficient independence for purposes of this research.

Results

Dependent t-tests indicated significant within-group improvements on all measures in both studies (Table 1).

Table 1: *Within-Group Changes in Study Measures Over 24 Weeks*

	Baseline		Week 24					Change		
	M	*SD*	*M*	*SD*	*t*	*p*	95% CI	*d*	*M*	*SD*
					Study 1					
Physical activity (METS/ week)	9.55	9.92	22.69	19.23	10.11	<.001	10.57,15.71	1.32	13.14	17.15
Weight (kg)	116.71	16.25	114.28	15.43	-7.37	<.001	-7.34,3.08	.15	-2.43	4.37
Δ Self-regulation for eating	21.63	5.82	25.68	6.85	9.23	<.001	3.19,4.92	.70	4.05	5.79
					Study 2					
Δ Self-regulation for physical activity[a]	21.37	4.70	31.26	5.47	16.45	<.001	8.70,11.07	2.10	9.89	7.31
Δ Self-regulation for eating	22.46	5.71	30.53	5.53	15.83	<.001	7.07,9.08	1.41	8.07	6.21
Δ Body areas satisfaction	2.17	0.61	2.77	0.69	11.51	<.001	0.49,0.70	.98	0.59	0.63
Δ Self-efficacy for controlled eating	97.17	33.66	129.45	31.82	10.96	<.001	26.46,38.09	.96	32.28	35.81
Δ Mood	21.00	17.02	5.13	15.10	-11.29	<.001	-18.64,-13.09	.93	-15.87	17.11

Note. Study 1, $n = 174$ ($df = 173$). Study 2, $n = 148$ ($df = 147$). Δ = change from baseline to Week 24.
d = Cohen's effect size for within-group changes: $M_{\text{Week 24}} - M_{\text{baseline}}/SD_{\text{baseline}}$.
[a]Change over 12 weeks.

Study 1

The prediction of change in weight from physical activity change was significant (Table 2). Change in self-regulation for controlled eating, but not energy expenditure (M = 11,221 kcal, SD = 8,818), was associated with physical activity over the course of the study and significantly mediated this relationship (Table 2). The overall mediation model was significant, $R^2 = .36$, $F(4, 169) = 23.85$,

$p < .001$. Within bivariate relationships, however, both change in self-regulation for eating and total energy expenditure significantly predicted weight change, r = -.47 and -.39, respectively, ps < .001.

Table 2: *Results of Mediation Analyses*

Predictor	Mediators	Outcome	Path a Coeff(SE)	Path b Coeff(SE)	Path c Coeff(SE)	Path c' Coeff(SE)	Indirect Effect Coeff(SE)
			Study 1				
Δ Physical activity		Δ Weight			-.14(.02)**		
	kcal expenditure		730.07(62.80)**	.00(.00)			-.01(.02)
							-.04, .02
	Δ Self-regulation for eating		.09(.02)**	-.19(.06)**			-.04(.01)
							-.07, -.01
						-.10(.02)**	
			Study 2				
Δ Self-reg. for physical activity		Δ Self-regulation for eating			.40(.06)**		
	Δ Body satisfaction		.08(.04)*	-.02(.15)			.00(.01)
							-.03, .03
	Δ Self-efficacy for eating		1.92(.38)**	.03(.01)*			.06(.03)
							.01, .14
	Δ Mood		-.58(15)**	-.07(.04)			.04(.02)
							.01, .10
						.30(.07)**	

Note. Study 1, n = 174. Study 2, n = 148. Δ = change from baseline to Week 24. Path a = predictor → mediators; Path b = mediators → outcome; Path c = predictor → outcome; Path c' = predictor → outcome (controlling for the mediators)
$^{*}p < .05$. $^{**}p < .01$

Study 2

Intercorrelations of variables at baseline suggested their adequate independence (Table 3). There was no significant difference between Study 1 and Study 2 samples on age, proportion of men, racial/ethnic make-up, attrition prior to study start, and baseline scores in self-regulation for eating, $t(320) = 1.28$, $p = .201$, 95% CI = -2.10, 0.44. Improvements in self-regulation for eating were significantly greater in the Study 2 sample, $F(1, 320) = 23.53$, $p < .001$, $\eta^2_p = .069$. Increase in self-regulation for physical activity was significantly related to increase in self-regulation for eating,

$r = .65$, $p < .001$. Changes in mood and self-efficacy for controlled eating, but not change in body areas satisfaction, significantly mediated the carry-over of change in self-regulation for physical activity to change in self-regulation for eating (Table 2). The overall mediation model was significant, $R^2 = .30$, $F(5, 142) = 11.03$, $p < .001$.

Table 3: *Intercorrelations Among Study 2 Measures at Baseline*

	1	2	3	4	5
1. Self-regulation for physical activity	—	—	—	—	—
2. Self-regulation for eating	.44**	—	—	—	—
3. Body areas satisfaction	.24**	.03	—	—	—
4. Self-efficacy for controlled eating	-.20*	-.13	-.45**	—	—
5. Mood	.16	.04	.23**	-.33**	—

Note. $n = 148$
*$p < .05$. **$p < .01$

Discussion

In Study 1, contrary to what was hypothesized, only change in self-regulation for controlled eating mediated the effect of changes in physical activity on weight change. Notably, energy expenditure *was not* a significant mediator (after controlling for self-regulation change). Although this is contrary to intuitive thought, the finding could be interpreted to mean that the primary value of increasing physical activity in obese individuals seeking weight loss is in its influence on the self-regulation of their eating (rather than its associated energy expenditure). This supports preliminary findings on the effects of physical activity on weight loss through psychosocial channels (Annesi & Marti, 2011; Baker & Brownell, 2000; Mata et al., 2009), and the realization that obese and deconditioned adults will not typically expend enough energy from initiating physical activity to meaningfully affect their weight. Pilot research indicated that there will be an estimated 150–200 kcal expenditure/session for this type of individual. Thus, 40–50 sessions would be required to reduce weight by just 1 kg (American College of Sports Medicine, 2009). Fortunately, the suggested emphasis on regularity of physical activity over maximization of energy expenditure within each session may reduce participants' associated discomfort (aversion) and improve adherence. Because the results indicated the importance of physical activity treatments' association with eating-related self-regulation, the nutrition treatment component in Study 1 was accordingly modified to further increase self-regulation.

In Study 2, specific attention given to building self-regulatory skills for controlled eating led to a doubling of effect size for its increase ($d = .70$ to $d = 1.41$). Additionally, Study 2 findings suggested that improvements in physical activity self-regulation occurring in the initial several months of treatment carry over to longer-term changes in self-regulation for eating. Future research will be required to determine how resilient these improvements are over durations longer than the 6 months of the present investigation because a sustained ability to control overeating is of great concern (Jeffery et al., 2000). The finding that changes in mood and self-efficacy mediated the relationship between changes in exercise- and physical activity-related self-regulation partially supported a proposed path based on social cognitive theory suggesting that mood, self-efficacy, and self-esteem affect “psychological resources” to maintain “dietary compliance” (Baker & Brownell, 2000, p. 315).

Limitations of this research should, however, also be noted. The contrast between changes in self-regulation for controlled eating associated with the two treatments was not derived from a completely random selection of participants. However, although it is possible that some unmeasured difference between the groups confounded results, salient demographic and psychological factors at baseline did not significantly differ. The use of gain (change) scores inflated the measurement error of the scales by combining error from two measurements times. Accounting for the dynamic process of changes in the psychosocial factors of interest was, however, an important aspect within this investigation. Although expectation and social support effects could have biased results, the use of a field design maximized generalizability of findings to practice settings, which may, overall, be considered an advantage (Glasgow, 2008). Although considerable replication is required across sample types (e.g., individuals with various degrees of overweight, individuals with diabetes), treatment venues (e.g., community health centers, psychotherapist-directed groups), and demographic characteristics (e.g., ethnicity, age) to increase confidence in the present findings, the results have distinct implications for community health promotion practitioners.

The importance of physical activity for self-managing eating was clear. A strong cognitive-behavioral approach to support regular physical activity appears critical, along with a treatment component addressing eating behaviors through emphasizing self-regulatory skills (possibly generalizing from the physical activity-support component). Although increased physical activity is, alone, associated with improved mood (Landers & Arent, 2007), it should be carefully monitored because findings indicated that negative mood will tend to degrade self-regulation processes. This is also true for self-efficacy to manage eating-related barriers, which may also benefit from direct attention such as recognition of small but important progress on process goals (e.g., increasing fruit and vegetable intake from three to five servings per day within 2 weeks).

Within this research, practical and theoretical implications of the relationships between physical activity, psychosocial changes, self-regulated eating, and sustaining weight loss were strong. It is recommended that research in that area is accelerated and intervention improvements be standardized in an effort to affect large-scale change in the persistent community health problem of obesity.

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