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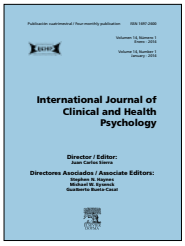

ORIGINAL ARTICLE

Generalization of theory-based predictions for improved nutrition to adults with morbid obesity: Implications of initiating exercise

James J. Annesi[a,*], Gisèle A. Tennant[b]

[a] *YMCA of Metro Atlanta and Kennesaw State University, United States*
[b] *YMCA Canada, Canada*

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Abstract Exercise is a robust predictor of long-term success with weight loss, and research based on social cognitive theory suggests that exercise program-induced changes in self-regulation, mood, and self-efficacy transfer to improved eating. These relationships were tested in adults with morbid obesity (overall M_{age} = 43 years; 86%female; $M_{body\ mass\ index}$ = 45 kg/ m^2) participating in a 6-month treatment of cognitive-behaviorally supported exercise paired with either standard nutrition education (n = 87) or cognitive-behavioral methods for controlled eating (n = 89). Based on multiple mediation analyses, improvements in self-regulation and self-efficacy were significantly associated with increased fruit and vegetable intake and reduced body mass index (BMI). The cognitive-behavioral nutrition methods were associated with greater improvements in fruit and vegetable intake and BMI, however, within both models, complete mediation was found after simultaneous entry of changes in self-regulation, mood, and self-efficacy, and exercise volume as mediators. Only the indirect effect of change in self-regulation was a significant (or marginally significant) independent mediator. Generalization of previously identified relationships between exercise program-induced improvements in psychosocial variables and improvements in nutrition and BMI were supported for individuals with morbid obesity. Based on these relationships, implications for behavioral treatments were discussed.
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PALABRAS CLAVE
Cognitivo-conductual;
Tratamiento;
Obesidad mórbida;
Ejercicio;
Experimento

Resumen El ejercicio es un robusto predictor a largo plazo de la pérdida de peso. La investigación basada en la teoría social-cognitiva sugiere que los cambios inducidos por programas de ejercicio en auto-regulación, estado de ánimo y autoeficacia se transfieren en mejor alimentación. Estas relaciones fueron probadas en adultos con obesidad mórbida (M_{edad} = 43 años; 86% mujeres; $M_{índice\ de\ masa\ corporal}$ = 45 Kg/ m^2) que participaron durante seis meses en un tratamiento cognitivo-conductual apoyado por ejercicio asociado con educación nutricional (n = 87) o métodos cognitivo-conductuales para alimentación controlada (n = 89). Las mejoras en la auto-regu-

*Corresponding author at: YMCA of Metropolitan Atlanta, 100 Edgewood Avenue, NE, Suite 1100, Atlanta, Georgia, 30303, USA.
E-mail address: jamesa@ymcaatlanta.org (J.J. Annesi).

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lación y auto-eficacia se asociaron con mayor consumo de frutas y verduras, y reducción del índice de masa corporal (IMC). Los métodos de nutrición cognitivo-conductuales se asociaron a incremento en consumo de frutas y verduras, y al IMC; en ambos modelos la mediación completa se obtuvo después de la entrada simultánea como mediadores de los cambios en auto-regulación, estado de ánimo, autoeficacia y volumen de ejercicio. Solo el efecto indirecto del cambio en auto-regulación fue un mediador independiente significativo (marginalmente significativo). La generalización de estas relaciones es aplicable a individuos con obesidad mórbida. Se discuten las implicaciones para los tratamientos conductuales.
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Results of behavioral weight loss treatments have typically been disappointing (Mann et al., 2007). This is especially true for adults with morbid obesity (i.e., body mass index [BMI] ≥ 40 kg/ m^2), for whom bariatric surgery has evolved into the treatment of choice (Bult, van Dalen, & Muller, 2008). Educating individuals on the need and methods for healthy eating practices has been a prominent, but uniformly ineffective and atheoretical, strategy (Mann et al., 2007). Cognitive-behavioral methods (e.g., goal setting, cognitive restructuring) (Bandura, 1986, 1997), and emphases on building self-regulatory skills and feelings of ability (i.e., self-efficacy), have performed only somewhat better (Cooper et al., 2010; Powell, Calvin, & Calvin, 2007; Unick et al., 2011; Wing, 2006). Exercise appears to be the best predictor of maintained weight loss (Fogelholm & Kukkomen-Harjula, 2000), although mechanisms for this are unknown. What is clear is that individuals with morbid obesity typically cannot tolerate exercise volumes corresponding to the recommended 150 min per week of moderate intensity activity (Garber et al., 2011). Additionally, the effect of exercise on increasing muscle mass and metabolism accounts for only a small portion of lost weight (Donnelly et al., 2009).

Baker and Brownell (2000) theorized that exercise participation-induced changes in mood, body image, self-efficacy, self-esteem, and coping leads to increased motivation and psychological resources and, following from this, improved eating and weight loss. In extensions of that work, research from Portugal (Mata et al., 2009; Teixeira et al., 2010), Finland (Hankonen, Absetz, Haukkala, & Uutela, 2009) and the U.S. (Annesi, 2011; Annesi & Marti, 2011) suggested the value of exercise for improving mood, self-regulatory skills, and self-efficacy; where such changes generalize or "carry over" to improved eating. It was proposed that even low volumes of exercise may foster these productive changes because exercise program participation, rather than physical output, is the critical factor. In two studies, it was demonstrated that only about 2 days per week of moderate exercise, 15 to 30 min per session, was required to induce a significant improvement in mood (depression, anxiety, and overall negative mood), which was suggested to be associated with a reduction in emotional eating (Annesi, 2003, 2012). Generalization of findings to persons with morbid obesity is unclear - especially considering that psychosocial factors are generally more negative for them than individuals with lower degrees of obesity (Wadden et al., 2006). Although longitudinal testing of such relationships and outcomes are only in their early stages (Unick, Jakicic, & Marcus, 2010), it was thought that long-term maintenance of weight loss may also benefit from a focus on establishing resilient self-regulatory skills to address barriers to persistence with healthy eating behaviors (e.g., increased consumption of fruits and vegetables).

Although great benefit appeared from the proposed transfer of exercise-related self-regulatory skills to self-regulatory skills for eating, and exercise-related self-efficacy to self-efficacy for controlled eating (Annesi, 2012; Hankonen et al., 2009; Mata et al., 2009; Texeira et al., 2010), it was unclear if additional effects could be realized from the addition of a cognitive-behaviorally based nutrition treatment component. This is important because as such exercise-weight loss research moves into practice, the most reliable, effective, and efficient methods should be sought to address behaviors related to the pressing health risk of obesity in a large scale manner (even as related theory may continue to systematically progress).

Thus, this investigation was conducted to address research questions related to the generalizability of previous findings to adults with morbid obesity, and to extend findings toward the development of improved (behavioral) obesity treatments. Specifically, for individuals with morbid obesity initiating cognitive-behaviorally supported exercise we aimed to determine: (a) if improvements in self-regulation, mood, and self-efficacy predict improved eating and BMI, (b) if a nutrition treatment component targeting improvements in self-regulation, mood, and self-efficacy is associated with a greater improvement in nutrition and BMI than a typical educationally based approach and, if so, are improvements in self-regulation, mood, self-efficacy, and volume of exercise mediators of these relationships, and (c) if volumes of exercise assumed to be manageable (e.g., the equivalent energy expenditure of about 2 sessions of moderate-intensity walking per week) induce significant improvements in the aforementioned psychosocial variables.

Similar to previous research that did not address morbid obesity, we hypothesized that changes in self-regulation and self-efficacy for controlled eating, and mood would be significantly associated with changes in fruit and vegetable consumption and BMI over 6 months. It was thought that the addition of a cognitive-behavioral nutrition treatment component would be associated with significantly greater improvements than that of inclusion of an educationally

based nutrition component; and changes in mood, self-efficacy, and self-regulation, but not exercise volume, would significantly mediate these relationships. Finally, in subsequent analyses that adjusted exercise volume to estimate typical daily outputs (as in previous research; Annesi, 2003, 2012), it was expected that a significant improvement in mood would require the equivalent of approximately two 15- to 30-min sessions of moderate exercise per week; and, based on the same research (Annesi, 2003, 2012), there would be with no significant further benefit from greater volumes. Whether changes in self-efficacy and self-regulation would demonstrate a similar pattern was left as a research question, without hypotheses. Suggestions by Hartley (2012) were used in the reporting of findings.

Method

Participants

Men and women responded to newspaper advertisements soliciting volunteers for research incorporating physical activity and nutrition instruction for weight loss to be completed in the southeastern U.S. Inclusion criteria were: (a) minimum age of 21 years, (b) BMI of 40 to 55 kg/m^2, and (c) no regular exercise (less than a mean of 20 min per week, based on self-report). Exclusion criteria were current or soon-planned pregnancy and/or taking medications prescribed for weight loss or a psychological condition that might affect survey responses (e.g., major depression). A statement of adequate physical health to participate was also required from a physician. Institutional review board approval was obtained, and written informed consent was received from all participants.

After minimal attrition due to reported problems with transportation (n = 1) and not returning phone calls or emails (n = 2), there was no significant difference in proportion of women (overall 86%), age (overall M = 42.7 years, SD = 9.9), BMI (overall M = 44.9 kg/m^2, SD = 3.7), and racial make-up (overall 46% White, 51% African American, and 3% of other racial/ethnic groups) between participants randomly assigned to a treatment of cognitive-behavioral exercise support plus nutrition education (n = 87) and the same cognitive-behavioral exercise support plus cognitive-behavioral nutrition methods (n = 89). The socioeconomic status of nearly all participants was middle-class.

Measures

Self-efficacy for controlled eating was measured by the Weight Efficacy Lifestyle Scale (Clark, Abrams, Niaura, Eaton, & Rossi, 1991). It has five subscales (i.e., Negative Emotions, Availability, Social Pressure, Physical Discomfort, and Positive Activities) derived from the hypothesized factors comprising self-efficacy for controlled eating that are summed for a total score. Responses to its 20 items (e.g., "I can resist eating even when others are pressuring me to eat") range from 0 *(not confident)* to 9 *(very confident)*. A higher score indicates greater self-efficacy. Reliability for subscale scores ranged from α = .70 to .90 (Clark et al., 1991). Subscales were shown to make up a global construct of eating self-efficacy (Clark et al., 1991); thus, the total score of the scale is used. Reliability for the total scale was α = .82 for the present sample.

Mood was measured by the Total Mood Disturbance scale of the Profile of Mood States Short Form, which is a 30-item aggregate measure of the subscales of *Tension, Depression, Fatigue, Confusion, Anger, and Vigor* (McNair & Heuchert, 2005). Because of the evidence of intercorrelations between subscales (McNair & Heuchert, 2005, p. 8, Table 8), the developers of the Profile of Mood States suggested the validity of this aggregate measure. Responses to feelings denoted by one- to three-word items (e.g., anxious, sad) "over the past week" range from 0 *(not at all)* to 4 *(extremely)*. A lower score indicates less mood disturbance. Scale score reliability ranged from α = .84 to .95, and test-retest reliability results over 3 weeks averaged .69 (McNair & Heuchert, 2005). For the present sample, scale score reliabilities ranged from α = .76 to .89, and was .74 for the total score.

Self-regulation for controlled eating was measured using a scale adapted from a recently validated inventory (Saelens et al., 2000). Consistent with suggestions from its developers, items were adapted to reflect the content of the treatment methods presently in use (e.g., "I say positive things to myself about eating well."). Responses to the 10 items range from 1 *(never)* to 5 *(often)*, and are summed. A higher score indicates greater self-regulation. Reliability for the present version was α = .81, and test-retest reliability over 2 weeks was .74 (Annesi & Marti, 2011). Reliability for the present sample was α = .78.

Exercise volume was measured by the Godin-Shephard Leisure-Time Physical Activity Questionnaire (Godin, 2011). It incorporates metabolic equivalents of tasks (METs), or the physiological energy cost based on physical activity intensity where a MET is equivalent to the use of 3.5 ml of O_2/kg/min (Meltzer & Jena, 2010) and 1 MET corresponds to sitting quietly and 7 to 10 METs reflect strenuous exercise. The Godin-Shephard Leisure-Time Physical Activity Questionnaire requires entry of number of weekly sessions of strenuous (approximately 9 METs; e.g., running), moderate (approximately 5 METs; e.g., fast walking), and light (approximately 3 METs; e.g., easy walking) exercise sessions for "more than 15 minutes" using descriptors of "heart beats rapidly", "not exhausting", and "minimal effort", respectively. For adults, test-retest reliability over 2 weeks was .74 (Godin, 2011). Construct validity was supported by significant correlations with accelerometer and maximum volume of oxygen uptake measurements (Jacobs, Ainsworth, Hartman, & Leon, 1993; Miller, Freedson, & Kline, 1994).

Quantity of servings of fruits and vegetables (combined) consumed "in a typical day" ("looking back over the last month") was based on the U.S. Food Guide Pyramid's descriptions of foods and their corresponding portion sizes. Responses from one item each for fruits and vegetables were summed. Research suggests that fruit and vegetable intake, alone, is a good predictor of quality of the diet (Rolls, Ello-Martin, & Tohill, 2004). Test-retest reliability over 2 weeks averaged .82, and concurrent validity was indicated through significant correlations of the present measure with lengthier food frequency questionnaires (Sharma et al., 2004).

A recently calibrated digital scale was used to measure weight (kg), and a stadiometer was used to measure height (m). BMI was calculated as kg/ m^2.

Procedure

Each participant reported to an assigned YMCA center in the southeastern U.S., received an orientation to study processes associated with his/her group, and was provided full access to the facility.

The cognitive-behavioral exercise support component was identical in both groups. It consisted of a standard protocol of six, 1-hour meetings with a trained wellness specialist over 6 months (Annesi & Johnson, 2013; Annesi, Unruh, Marti, Gorjala, & Tennant, 2011). These one-on-one sessions included an orientation to exercise apparatus, but most time was spent conferring in an office. Long-term goals were identified, documented, and broken down into process-oriented short-term goals where progress was tracked graphically. Instruction in additional self-regulatory skills including cognitive restructuring, stimulus control, behavioral contracting, and relapse prevention was given during the sessions. Specific modalities used in exercise plans (e.g., treadmill; walking on an indoor track) were based on each participant's preference. Widely used exercise recommendations (i.e., 150 min weekly of moderate cardiovascular activity; Garber et al., 2011) were described, but it was also stated that any volume (i.e., intensity, duration, and frequency) of exercise may be beneficial.

The content of the nutrition components of the two groups differed considerably, with one emphasizing nutrition education and one emphasizing the use of cognitive-behavioral methods to address barriers to healthful eating. In the nutrition education group, a standardized protocol (Kaiser Permanente Health Education Services, 2009) of six, 1-hour sessions was administered by a certified wellness specialist in a small group format over 3 months beginning 4 to 6 weeks after initiating exercise. Examples of program components were: (a) understanding carbohydrates, protein, fats, and calories; (b) healthy recipes; (c) weekly menu planning; (d) low-fat snacking; and (e) stocking a healthy kitchen. The cognitive-behavioral nutrition group had the identical format for meetings, however the protocol included: (a) establishing caloric goals, (b) logging all food and calorie intake, (c) regular self-weighing, (d) cognitive restructuring, (e) relapse prevention training, (e) cues to overeating, and (f) progressive relaxation. In both groups, increasing fruit and vegetable intake was emphasized during each session.

Wellness specialists administering the protocols were blind to the purposes this investigation. Treatment fidelity was assessed by trained staff and, if deviations occurred, corrective measures were immediately taken by YMCA supervisors in cooperation with study administrators. Assessments were administered in a private area at baseline and Month 6, with an additional measurement of exercise volume taken at Month 3.

Data analysis

An intention-to-treat format was incorporated where data from all participants initiating treatment were included in the analyses. The 17%of participants' measure scores (that could not be obtained at Month 6) were imputed using the expectation-maximization algorithm (Schafer & Graham, 2002). Statistical significance was set at $\alpha = .05$ (two-tailed), throughout.

Change scores in self-regulation and self-efficacy for controlled eating, mood, fruit and vegetable intake, and BMI were calculated as differences between scores at baseline and Month 6, unadjusted for their baseline value. To assess relationships of changes in self-regulation, self-efficacy, and mood with fruit and vegetable intake and BMI changes; effects of treatment type (inclusion of nutrition education or cognitive-behavioral nutrition methods) on changes in fruit and vegetable intake and BMI; and the mediation of changes in self-regulation, self-efficacy, mood, and overall volume of exercise (the mean of exercise volumes at their three measurement times), two mediation models were specified using a bias-corrected bootstrapping procedure incorporating 10,000 re-samples (Preacher & Hayes, 2008). An additional mediation model assessed whether fruit and vegetable intake changes and exercise volume mediated the relationship of treatment type and BMI change.

A subsequent analysis was conducted so that findings related to exercise volume and associated changes in the psychosocial variables could be determined in a manner that enabled contrasts with previous related studies of individuals not specifically with morbid obesity (Annesi, 2003, 2012). This required that the present measure of exercise intensity (METs) also be converted to include estimates of duration and frequency. Thus, data from the two treatment conditions were first aggregated, then one-way ANOVAs with Bonferroni follow-up were calculated to contrast the mean differences in changes in self-efficacy, mood, and self-regulation when less than 10 METs (the equivalent of less than 2 moderate-intensity sessions of exercise per week of between 15 and 30 min), between 10 and 15 METs (the equivalent of between 2 and 3 moderate-intensity sessions of exercise per week of between 15 and 30 min), and greater than 15 METs (the equivalent of greater than 3 moderate-intensity sessions of exercise per week of between 15 and 30 min) were completed.

Results

Descriptive statistics of study measures at baseline and Month 6, mean change scores, and their associated effect sizes are given in Table 1. There were no significant differences between the treatment groups at baseline in self-efficacy for controlled eating, $F_{(1, 174)} = 0.49$, $p = .826$; mood, $F_{(1, 174)} = 1.25$, $p = .266$; self-regulation for controlled eating, $F_{(1, 174)} = 0.74$, $p = .392$; fruit and vegetable intake, $F_{(1, 174)} = 0.53$, $p = .466$; and BMI, $F_{(1, 174)} = 0.13$, $p = .911$. Change scores on the variables demonstrated low to moderate intercorrelations (Table 2). Exercise volume did not significantly differ between the two treatment conditions, $F_{(1, 174)} = 0.09$, $p = .767$ (overall $M = 16.90$ METs [$SD = 12.25$] or approximately 3.38 sessions per week [$SD = 2.45$] of moderate intensity exercise for between 15 and 30 min per session).

Table 1 Changes in study measures over 6 months.

	Baseline		Month 6				
	M	*SD*	*M*	*SD*	M_{change}	*SD*	*d*
Self-efficacy for controlled eating							
Nutrition education group	96.81	33.03	115.56	33.95	18.74	31.08	.57
Cognitive-behavioral nutrition group	95.64	37.51	117.39	40.88	21.75	34.02	.58
Overall sample	96.22	35.27	116.49	37.52	20.26	32.54	.58
Mood							
Nutrition education group	22.38	17.14	12.77	18.96	−9.61	15.56	.56
Cognitive-behavioral nutrition group	19.48	17.25	9.85	18.62	−9.63	15.31	.56
Overall sample	20.91	17.21	11.30	18.80	−9.62	15.39	.56
Self-regulation for eating							
Nutrition education group	21.37	6.24	25.45	7.08	4.08	5.49	.65
Cognitive-behavioral nutrition group	22.15	5.78	27.79	7.41	5.64	6.01	.98
Overall sample	21.76	6.01	26.63	7.32	4.87	5.79	.81
Fruit and vegetable intake per day							
Nutrition education group	4.40	2.17	4.87	2.14	0.47	1.14	.22
Cognitive-behavioral nutrition group	4.62	1.72	5.51	1.99	0.89	1.60	.52
Overall sample	4.51	1.96	5.19	2.08	0.68	1.40	.35
Body mass index (BMI)							
Nutrition education group	44.94	3.77	43.89	4.00	−1.06	1.57	.28
Cognitive-behavioral nutrition group	44.88	3.72	43.22	4.05	−1.66	2.39	.47
Overall sample	44.91	3.73	43.55	4.03	−1.36	2.04	.36

Note. Nutrition education group $n = 87$. Cognitive-behavioral nutrition group $n = 89$. Overall sample $N = 176$. *d* denotes Cohen's effect size for within-group changes: $M_{Month\ 6} - M_{baseline} / SD_{baseline}$.

Table 2 Intercorrelations among study measures (N = 176).

	1	2	3	4	5
1. Δ Self-efficacy for controlled eating					
2. Δ Mood	−.54	...			
3. Δ Self-regulation for controlled eating	.62	−.56	...		
4. Δ Fruit and vegetable intake	.45	−.35	.47	...	
5. Δ Body mass index (BMI)	−.46	.37	−.50	−.37	...

Note. All intercorrelations $p < .001$.

Results of the mediation analyses are reported in Table 3. Changes in self-regulation and self-efficacy were significantly associated with change in fruit and vegetable intake. The total effect of treatment type on fruit and vegetable intake change was significant, with greater increase associated with the cognitive-behavioral nutrition treatment (Table 3, top panel, Path *c*). This relationship was, however, no longer significant after entry of the four mediators (Table 3, top panel, Path *c'*), indicating complete mediation. The overall mediation model was significant, $R^2 = .27$, $F_{(5, 170)} = 12.66$, $p < .001$. Only the indirect effect of change in self-regulation independently mediated the relationship between treatment type and change in fruit and vegetable intake (Table 3).

Changes in self-regulation, self-efficacy, and volume of exercise were significantly associated with BMI change in the negative direction. The total effect of treatment type on change in BMI was significant, with greater reduction associated with the cognitive-behavioral nutrition treatment (Table 3, middle panel, Path *c*). This relationship was, however, no longer significant after entry of the four mediators, indicating complete mediation (Table 3, middle panel, Path *c'*). The overall mediation model was significant, $R^2 = .34$, $F_{(5, 170)} = 17.81$, $p < .001$. The indirect effect of change in self-regulation was a marginally significant independent mediator of the relationship between treatment type and BMI change.

Changes in exercise volume and fruit and vegetable intake were significantly associated with change in BMI. The overall mediation model was significant, $R^2 = .31$, $F_{(3, 172)} = 25.83$, $p < .001$.

In the subsequent analysis, there were no significant differences in baseline scores on the three psychosocial variables based on mean volume of exercise ($ps > .20$). Thus, after aggregating data, for participants completing weekly volumes of less than 10 METs (the equivalent of less than 2 sessions weekly; $n = 58$ or 33% of the sample),

Table 3 Results from mediation analyses (N = 176).

Predictor	Mediator	Outcome	Path *a*	Path *b*	Path *c*	Path *c'*	Indirect effect	R^2
			Coef. (*SE*)	Coef. (*SE*)	Coef. (*SE*)	Coef. (*SE*)	Coef. (*SE*)	
							95%CI	
Treatment	Δ Self-efficacy	Δ Fruit & Veg.	3.01 (4.92)	.01 (.00)**			03 (.06)	
							−.056, 183	
Treatment	Δ Mood	Δ Fruit & Veg.	−.02 (2.33)	−.01 (.00)			.00 (.03)	
							−.055, .064	
Treatment	Δ Self-regulation	Δ Fruit & Veg.	1.64 (.87)	.06 (.02)**			.10 (.07)	
							.008, .349	
Treatment	Δ Vol. of exercise	Δ Fruit & Veg.	.55 (1.85)	.00 (.01)			.00 (.02)	
							−.025, .053	
Treatment	(all of above)	Δ Fruit & Veg.			.42 (.21)*	.29 (.19)		.27**
Treatment	Δ Self-efficacy	Δ BMI	3.01 (4.92)	−.01 (.00)*			-.04 (.07)	
							−.258, .063	
Treatment	Δ Mood	Δ BMI	−.02 (2.33)	−.00 (.01)			.00 (.04)	
							−.073, .081	
Treatment	Δ Self-regulation	Δ BMI	1.50 (.87)	−.06 (.03)*			−.10 (.08)	
							−.343, .005	
Treatment	Δ Vol. of exercise	Δ BMI	−.86 (2.86)	−.03 (.01)**			.03 (.10)	
							−.165, .250	
Treatment	(all of above)	Δ BMI			−.61 (.31)*	−.50 (.26)		.34**
Treatment	Δ Vol. of exercise	Δ BMI	−.86 (2.86)	−.05 (.01)**				
Treatment	Δ Fruit & Veg.	Δ BMI	.24 (.23)	−.29 (.09)**				
Treatment	(all of above)	Δ BMI			−.61 (.31)*	−.58 (.26)*		.31**

Note. The Delta symbol (Δ) denotes change from baseline to Month 6. Path *a* = predictor → mediator; Path *b* = mediator → outcome; Path *c* = predictor → outcome; Path *c'* = predictor → outcome (controlling for mediators).
* $p < .05$; **$p < .01$.

between 10 and 15 METs (the equivalent of 2 to 2.9 sessions weekly; *n* = 48 or 27% of the sample), and greater than 15 METs (the equivalent of greater than 3 sessions weekly; *n* = 70 or 40% of the sample), mean change scores for self-efficacy were 9.58 (*SD* = 26.75), 24.56 (*SD* = 33.75), and 26.16 (*SD* = 34.29), respectively; for mood were −2.43 (*SD* = 10.19), −11.08 (*SD* = 15.62), and −14.57 (*SD* = 16.70), respectively; and for self-regulation were 2.22 (*SD* = 4.26), 5.08 (*SD* = 6.07), and 7.01 (*SD* = 5.94), respectively. Mean changes in mood, $F_{(2, 173)} = 12.16$, $p < .001$, $\eta^2 = .123$; self-efficacy, $F_{(2, 173)} = 4.90$, $p = .009$, $\eta^2 = .054$; and self-regulation, $F_{(2, 173)} = 12.16$, $p < .001$, $\eta^2 = .123$, significantly differed based on category of weekly exercise volume. This denoted large effect sizes for mood and self-regulation, and a medium effect for self-efficacy. Follow-up tests indicated that, for each of the three psychosocial variables assessed, the MET values consistent with 2 to 2.9, and 3 or more sessions of exercise per week were associated with significantly more improvement than MET values consistent with less than 2 sessions per week. MET values consistent with 2 to 2.9 and 3 or more sessions per week did not significantly differ from one another.

Discussion/conclusions

Findings suggested that exercise program-induced improvements in self-regulation and self-efficacy for controlled eating predicts increased fruit and vegetable consumption and reduced BMI in individuals with morbid obesity, similar to that of adults of lower degrees of overweight and obesity (Annesi, 2012; Teixeira et al., 2010). Consistent with previous research, adding a nutrition component that targets increases in self-regulation, self-efficacy, and improved mood to behaviorally supported exercise appeared to be useful in the present sample type – especially through the building of self-regulation for improved eating where effect sizes were medium for the more traditional nutrition education treatment and large for the cognitive behavioral nutrition treatment (Annesi, 2012; Annesi & Marti, 2011; Mata et al., 2009). The finding that the effect size for fruit and vegetable intake increase was small in the nutrition education group, and moderate in the cognitive behaviorally trained group, has significant implications for the design of weight-management treatments. Moreover, it supports the previously suggested importance of self-regulation emanating from social cognitive theory (Annesi, 2012; Mata et al., 2009; Texeira et al., 2010; Wing, 2006). If well-learned by a severely obese individual seeking weight loss, self-regulatory skills might also serve to facilitate persistence with the long and formidable path toward a healthy weight, and maintenance of lost weight (Andrade et al., 2010; Annesi, 2012; Unick et al., 2011; Wing, 2006). Based on the present findings, future development of evidence-based treatments of supported

exercise and nutrition change may, together, serve to optimize effects on weight management.

The equivalent of only 2 moderate-intensity exercise sessions per week, for 15 to 30 min per session, was associated with as much improvement in self-regulation, self-efficacy, and mood as with greater volumes. Considering that adherence to exercise programs in general, and specifically to volumes approaching the "public health" recommendation of about 5 sessions per week, has been problematic for persons with severe overweight (Annesi et al., 2011; Garber et al., 2011), the aforementioned result may also be important for the architecture of weight loss interventions through allocation of manageable exercise volumes. The comparatively low volume of exercise found necessary for improvements in self-regulation, self-efficacy, and mood was consistent with previous research on the relationship of exercise and mood change (Annesi, 2003, 2012) where, after the minimal program participation of 2 sessions per week was attained, a dose-response relationship (i.e., more exercise, more improvement in mood) was not found. Thus, the finding of significant mood effects being associated with minimal volume was extended to improvements in self-regulation and self-efficacy. Knowledge of these manageable volumes of exercise required for beneficial effects may be especially attractive to persons with morbid obesity who consider initiating programs, but may not do so because of anticipation of an extreme physical burden. Determination of whether the relationship of exercise volume and psychosocial change is related to physiological factors or, rather, exercise volume serves as a proxy for commitment to behavioral change, requires future investigation.

A strength of this investigation was its use of accepted theory and recent research findings to generate salient psychosocial variables for the study of eating behavior change in an at-risk subgroup. Additionally, the real-world setting, while challenging internal validity through possible expectation and social support effects (i.e., group intervention) had the advantage of allowing for rapid generalization of findings to practice. Benefits of such practical research settings outweighing their disadvantages has been strongly articulated (Green, Glasgow, Atkins, & Stang, 2009). The standardization of both the exercise support and nutrition treatment components enables their large-scale use in a variety of practical settings (e.g., YMCAs, recreation departments). This is an improvement on treatments that require administration by highly credentialed professionals in a time-consuming and expensive manner. The design also enables future researchers to add (or subtract) other psychosocial variables of interest (e.g., social support) or aspects of treatment (e.g., imagery) for their comparative effect.

Limitations included the use of change scores that inflate measurement error by combining the error linked to their scores at baseline and at Month 6. Also, there was a somewhat brief 6-month design. Because long-term weight loss has been a great problem, studies over multiple years are greatly needed. After confirmatory analyses of the proposed relationships of exercise, psychosocial change, and eating and weight change are conducted, long-term investigation of the emerging propositions across sample types (e.g., cancer survivors, individuals with diabetes) will be required. Another limitation was the use of a volunteer sample that may have been highly motivated. Incorporation of individuals assertively referred by medical professionals might lessen this potential confound in the future. Also, a more comprehensive assessment of nutrition (e.g., food diary; full food frequency questionnaire) may benefit extensions of this research. Although walking appeared to be the overwhelming form of exercise chosen by the participants, this was not specifically assessed. Thus, extensions of this research might also consider the effect of exercise modality on changes in relevant psychosocial factors and diet.

In conclusion, it appears that supported exercise in manageable dosages has great potential for improving psychosocial variables that may be associated with gaining control of eating behaviors and weight in persons with morbid obesity. Attending to these behavioral factors in a nutrition, as well as exercise, context may maximize effects. Longitudinal testing will be useful to evaluate the present findings over the longer term, and extend the assessments made into a context of maintained behavioral change.

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