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Abstract

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Keywords

mood, obesity, self-efficacy, self-regulation, emotional eating

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The author has no conflicts of interest to declare, financial or otherwise.

Indirect Effect of Self-regulated Exercise on Mood Through Self-efficacy Changes

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Abstract

To improve deficient long-term effects, an improved understanding of psychosocial factors occurring within behavioral obesity treatments is required. The aim of this study was to suggest paths from changes in self-regulation toward reduced negative mood to inform the direction of more comprehensive investigations and treatment foci. Initially low active women (N = 87) participated in a theory-driven community-based behavioral obesity program emphasizing self-regulation and exercise. There were significant (ps < .001) improvements in exercise amounts, exercise-related self-regulation and self-efficacy, negative mood, and emotional eating during the weight loss phase of baseline–Month 6, and significant (ps < .01) deteriorations during the weight-loss maintenance phase of Month 6–Month 24. During both phases, significant paths (95% CIs [-0.31, -0.01], [-0.14, -0.01], and [-0.50, -0.01]) from changes in self-regulation toward reduced negative mood were through self-efficacy, but not exercise change itself. The mood change-emotional eating change relationships were significant (95% CIs [0.16, 0.39] and [0.19, 0.48]). Although extensions of this research are required to better understand long-term obesity intervention processes, the present findings suggest importance of treatment foci on identified psychological mechanisms of exercise treatment-mood change relationships.

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Introduction

An enhanced understanding of the dynamic changes in psychosocial factors occurring within behavioral obesity treatments is required to improve the consistently poor results transpiring beyond the initial several months (Gomez-Rubalcava et al., 2018; MacLean et al., 2015; Pi-Sunyer, 2022). Although weight loss is reliably associated with controlled eating and increased exercise, those behaviors have been short-lived within almost all behavioral treatments (MacLean et al., 2015; U.S. Preventive Services Task Force et al., 2018). Psychosocial mediators of weight-loss behaviors include self-control, self-regulation, self-concept, self-efficacy, and mood (Annesi, 2020; Annesi & Marti, 2011; Baker & Brownell, 2000; Stacey et al., 2015; Teixeira et al., 2015). Self-regulation theory (Vohs & Baumeister, 2016) posits that under the conditions of appropriate attention, self-regulatory skills can be strengthened to prevail over common lifestyle challenges that undermine goal-driven behavioral changes (e.g., boredom, slow results, discomfort). When barriers/challenges are overcome through recruitment of such self-regulatory methods, increased self-efficacy occurs (Bandura, 1997), which motivates persistence. Through processes termed "coaction," both increased self-regulation and self-efficacy associated with exercise might carry over to eating behaviors (Johnson et al., 2014). Although primarily tested over periods of just several months (Annesi & Eberly, 2022), exercise-associated mood improvements (Arent et al., 2020) have

been associated with reductions in emotional eating and weight (Koenders & van Strien, 2011). Consolidation of disparate research findings on theory-based associations among behavioral correlates of weight management in a manner capable of impacting obesity interventions for large scale application has, however, been lacking (Lv et al., 2017).

In a recently published causal chain model on the association of exercise with psychosocial correlates of improved eating and weight change over both the weight loss phase (program start to 6–9 months) and weight-loss maintenance phase (beyond 6–9 months), exercise-induced mood change held substantial importance (Annesi, 2020). Within that model, the proposition that treatment-associated increases in self-regulation focused on adherence to exercise would be associated with mood improvements both directly (via better self-management of negative feelings) and indirectly (through increased self-efficacy that occurs when learned self-regulatory skills are leveraged to overcome persistent behavioral challenges/barriers) was supported. The model also accounted for expected deteriorations in the above variables after the weight loss phase (Annesi, 2020).

Although consistent with the strength model of self-regulation (Baumeister et al., 2018), and key tenets of social cognitive (Bandura, 1986) and self-efficacy (Bandura, 1997) theories, such behavioral explanations run contrary to biochemical hypotheses positing that exercise-associated mood improvements result from endorphin-, serotonin-, norepinephrine-, and/or endocannabinoid-related changes in the brain (Arent et al., 2020). Such biochemical explanations have been challenged based on an absence of a dose-response relationship between exercise amount and degree of observed mood change (Annesi, 2021).

While the bases of the effects of exercise on mood have been explored (but remain unclear; Arent et al., 2020), impacts of improved mood on reductions in emotional eating and weight received minimal research attention. Emotional eating might be one of the most critical focal points for behavioral obesity treatments because of its strong effect on weight (Koenders & van Strien, 2011), particularly in women (Péneau et al., 2013). A recent study indicated a significant regression path from changes in exercise→mood→emotional eating→weight over both 6 and 12 months (Annesi & Eberly, 2022). However, it is during the second year and beyond where consequential changes in health risks materialize. Therefore, inclusion of analyses during that period will be important in related research.

Thus, the present research brief incorporating a single group of low-active women participating in a community-dispensed obesity program aimed to inform both proximate treatment revisions and more comprehensive related investigations. To accommodate analyses into the weight-loss maintenance phase, the length of the study was 24 months. The following hypotheses were given:

1. Within-group changes in exercise, exercise-related self-regulation, negative mood, exercise-related self-efficacy, emotional eating, and weight will significantly improve during the weight-loss phase and deteriorate during the weight-loss maintenance phase.
2. Exercise self-efficacy, rather than exercise itself, will significantly mediate the self-regulation-negative mood change

relationship during both the weight-loss and weight-loss maintenance phases.
3. Changes in negative mood and emotional eating will be significantly related.

Methods

Participants

Data were from a program of field-based inquiries in the United States contrasting various educational and behavioral approaches for weight management. Based on the foci of the present investigation, women volunteers (≥ 21 years-of-age, with obesity and a goal of weight loss) who self-reported ≤ 2 bouts of moderate exercise/week on average and participated in the cognitive-behavioral obesity program described in the Procedures section below were included. Although definitions for being sedentary are multifaceted and presently unclear, the above cut-point could, at minimum, be considered a low activity level because it is well below recommended amounts for health of 150 minutes/week (~ 5 days/week) of moderate exercise (Piercy et al., 2018) and yield possibilities for exercise-related mood improvements (Magnon et al., 2018). Additional inclusion criteria were no medical contraindication or pregnancy and no change in any prescribed psychotropic medication over the previous 6 months. The sample (N = 87) age M was 39.7 years (SD = 8.8), BMI M was 34.7 kg/m^2 (SD = 3.1), and family income Mdn was US$59,000/year. Race/ethnicity was 77% white, 18% black, 4% Hispanic, and 1% other. A university institutional review board approved the study protocol and the written informed consent required from all participants prior to study start. Ethical mandates of the Declaration of Helsinki and the American Psychological Association were upheld.

Measures

Exercise was measured by the Leisure-Time Physical Activity Questionnaire (Godin, 2011). Number of ≥ 15-minute bouts completed in the previous 7 days ranging in intensity from "mild (minimal exertion)" (e.g., easy walking-3 metabolic equivalents [METs]) to "strenuous (heart beats rapidly)" (e.g., running-9 METs) was self-reported. Number of bouts × corresponding MET value was then summed. Concurrent validity was suggested through correspondences with treadmill stress test and accelerometry scores, with 2-week test-retest reliability at .74 (Pereira et al., 1997). It has been suggested that a Leisure-Time Physical Activity Questionnaire score of 24 corresponds to the minimum recommended exercise/physical activity amount for health (Godin, 2011).

Exercise-related self-regulation was measured by a 10-item scale (Annesi & Marti, 2011) specifying present use of self-regulatory methods that were previously proposed in a taxonomy of skills (Michie et al., 2011) that could be fostered and advanced under the domain of social cognitive theory (e.g., relapse prevention; cognitive restructuring; "I say positive things to myself about being physically active"). Responses ranging from 1 (*never*) to 4 (*often*) were summed. In adults with obesity, (Cronbach's) α = .79, with 2-week test-retest reliability at .78 (Annesi & Marti, 2011). For the present sample, α = .74.

Negative mood was measured by the 30-item Profile of Mood States-brief (McNair & Heuchert, 2009). Items reflected dimensions of tension/anxiety, dejection/depression, anger/hostility, fatigue, confusion, and vigor (e.g., "sad," "uneasy," "energetic") recalled from the previous 7 days. Responses ranging from 0 (*not at all*) to 4 (*extremely*) were

summed (vigor items were negatively keyed). In women, α = .90, with 3-week test-retest reliability averaging .70. There were strong correspondences with well-validated tests of longer lengths (McNair & Heuchert, 2009). For the present sample, α = .84.

The 5-item Exercise Self-efficacy Scale (Marcus et al., 1992) measured confidence in effectively dealing with challenges to exercise (i.e., barriers self-efficacy). Responses to items such as, "How confident are you that you can persist with exercising when you are tired?" ranged from 1 (*not at all confident*) to 11 (*very confident*), and were summed. In adults, αs = .76–.82, with 2-week test-retest reliabilities at .74–.78 (Marcus et al., 1992). For the present sample, α = .79.

Fifteen items of the Emotional Eating Scale (Arnow et al., 1995) required responses to "the extent the following feelings presently lead you to feel an urge to eat" ranging from 0 (*no desire to eat*) to 4 (*an overwhelming urge to eat*). The responses – associated with feelings of depression, anxiety, and anger/frustration (e.g., "blue," "irritated") – were summed. In women with obesity, α = .77, with 2-week test-retest reliability at .79 (Arnow et al., 1995). For the present sample, α = .75.

Weight was measured to the nearest 0.1 kg by a recently calibrated digital floor scale after the participant removed their shoes and any heavy outer-clothing.

Procedures

Current staff members of the participating community health-promotion sites were trained in and administered a structured cognitive-behavioral obesity treatment protocol guided by principles of the strength model of self-regulation (Baumeister et al., 2018) and key tenets of social cognitive and self-efficacy theories (Bandura, 1986, 1997). The process focused first on exercise adherence via six, 30- to 40-minute one-on-one meetings held in a private office at baseline and Weeks 2, 6, 10, 18, and 26. Their focal points were: (a) building self-regulatory skills (e.g., proximal goal setting and incremental progress feedback, cognitive restructuring), (b) fostering self-efficacy through perceived progress associated with self-regulating through lifestyle barriers, and (c) exercise-associated mood change. Although the U.S. governmental recommendation of moderate exercise for promoting health (Piercy et al., 2018) was presented to participants, any amount above what was previously completed by a participant was suggested to them as being beneficial. At Week 10, 50- to 60-minute group-based sessions of 10–15 participants focused on controlled eating began and were held every 2 weeks through Week 56. It was intended that self-regulation and self-efficacy carry over from exercise to improved eating behaviors such as increased fruit/vegetable consumption and reduced sugar intake. Monthly phone follow-ups of ~10 minutes aimed to bolster learned self-regulatory skills during the second treatment year.

Structured fidelity checks were completed on 12% of protocol sessions by study staff not involved in instruction. Because protocol compliance was strong, only a small number of interactions between study staff and treatment instructors was required. They were primarily associated with maintaining assigned timeframes within treatment components. The same study staff completed measurements in a private area at baseline, Month 6, and Month 24.

Data Analysis

An intention-to-treat format was facilitated by imputing the 17% of missing scores using the expectation-maximization algorithm (Little & Rubin, 2014). Imputation was conducted independently for the data set

used within this investigation. The required criteria for no systematic bias in the missing data (White et al., 2011) were met. Based on the planned regression models, a sample size of 84 was required to detect a moderate effect (f^2 = .15) at the statistical power of .80 (Cohen et al., 2003). Variance inflation factors of < 2.0, indicated acceptable multicollinearity.

Within-group changes in exercise, weight, and the psychosocial measures were separately assessed for the weight loss phase and weight-loss maintenance phase using dependent samples *t* tests, and Cohen's *d* to appraise effect sizes. Separate serial multiple mediation models were next fit where the identified changes in exercise and exercise self-efficacy were sequentially entered as mediators of the prediction of mood change by change in self-regulation during the weight-loss and weight-loss maintenance phases. For sensitivity analyses, bivariate associations between changes in mood and emotional eating were calculated. Significance was set at $\alpha < .05$ (two-tailed), throughout. SPSS Version 28 (IBM, Armonk, NY) was used, incorporating the PROCESS Version 3.5 macro-instruction Model 6 with 20,000 percentile-method bootstrap resamples (Hayes, 2018).

Results

Participants' weight at Month 6 (*M* = 88.28 kg, *SD* = 12.42) was significantly less than their baseline weight (*M* = 94.50 kg, *SD* = 12.61), $t(86) = 13.23$, $p < .001$ $d = 1.42$ (6.7% weight loss). Weight at Month 24 (*M* = 89.00 kg, *SD* = 12.81) was greater than weight at Month 6, but did not reach statistical significance, $t(86) = -1.35$, $p = .180$, $d = -0.15$ (regain of 0.8%). There were significant within-group improvements in exercise amount, exercise-related self-regulation, negative mood, exercise-related self-efficacy, and emotional eating during the weight-loss phase, and significant deteriorations of those gains during the weight-loss maintenance phase (Table 1).

The overall serial multiple mediation model predicting change (Δ) in negative mood during the weight loss phase was significant, $R^2 = .15$, $F(3, 83) = 4.89$, $p = .004$. The direct effect of Δself-regulation→Δnegative mood (Figure 1A; Path *c′*) was significant. Significant indirect paths were: Δself-regulation→Δexercise self-efficacy→Δnegative mood, B = -0.14, $SE_B = 0.08$, 95% CI [-0.31, -0.01], and Δself-regulation→Δexercise→Δexercise self-efficacy→Δnegative mood, B = -0.06, $SE_B = 0.03$, 95% CI [-0.14, -0.01] (Figure 1A). The overall mediation model predicting change in negative mood during the weight-loss maintenance phase was significant, $R^2 = .10$, $F(3, 83) = 2.99$, $p = .036$. The direct effect of Δself-regulation→Δnegative mood (Figure 1B; Path *c′*) was not significant. The only significant indirect path was:

Δself-regulation→Δexercise self-efficacy→Δnegative mood, B = -0.19, $SE_B = 0.13$, 95% CI [-0.50, -0.01] (Figure 1B). Within both the weight-loss and weight-loss maintenance phases, there was no significant path toward Δnegative mood that passed directly through Δexercise.

Change in negative mood predicted Δemotional eating during both the weight-loss phase, B = 0.27, $SE_B = 0.06$, $\beta = .46$, $p < .001$, 95% CI [0.16, 0.39], and weight-loss maintenance phase, B = 0.33, $SE_B = 0.07$, $\beta = .44$, $p < .001$, 95% CI [0.19, 0.48].

Table 1

Within-group Changes During the Weight Loss Phase (Baseline–Month 6) and Weight-loss Maintenance Phase (Month 6–Month 24)

Measure	Baseline		Month 6		Change from Baseline–Month 6					Month 24		Change from Month 6–Month 24				
	M	*SD*	*M*	*SD*	*M*	*SD*	*t*(86)	95% CI	*d*	*M*	*SD*	*M*	*SD*	*t*(86)	95% CI	*d*
Exercise self-regulation	30.32	5.54	32.66	4.55	2.33	6.54	17.60**	10.94, 13.72	1.89	29.76	7.35	-2.89	6.47	4.17**	-4.27, -1.51	-0.45
Negative mood	25.29	15.27	2.54	10.31	-22.75	14.72	14.42**	-1.23, -19.61	1.55	8.82	14.62	6.28	12.82	4.57**	-3.55, -9.01	-0.49
Exercise (METs/week)	3.56	3.83	33.44	18.03	29.87	18.31	15.22**	25.97, 33.77	1.63	25.55	16.19	-7.89	16.90	4.35**	-11.49, -4.28	-0.47
Exercise self-efficacy	28.24	11.33	34.91	10.57	6.67	11.85	5.25**	4.14, 9.19	0.56	28.29	12.10	-6.62	1.18	5.61**	-8.97, -4.28	-0.62
Emotional eating	25.83	11.48	16.52	9.60	-9.30	8.71	9.97**	-11.16, -7.45	1.07	19.15	10.99	2.63	9.59	2.56*	0.58, 4.67	-0.49

Note. $N = 87$. d = Cohen's measure of within-group effect size where 0.20, 0.50, and 0.80 = small, moderate, and large effects, respectively. A negative d value indicates change in the unfavorable direction. 95% CI = 95% confidence interval.
*$p \leq .01$. **$p \leq .001$ (two-tailed tests).

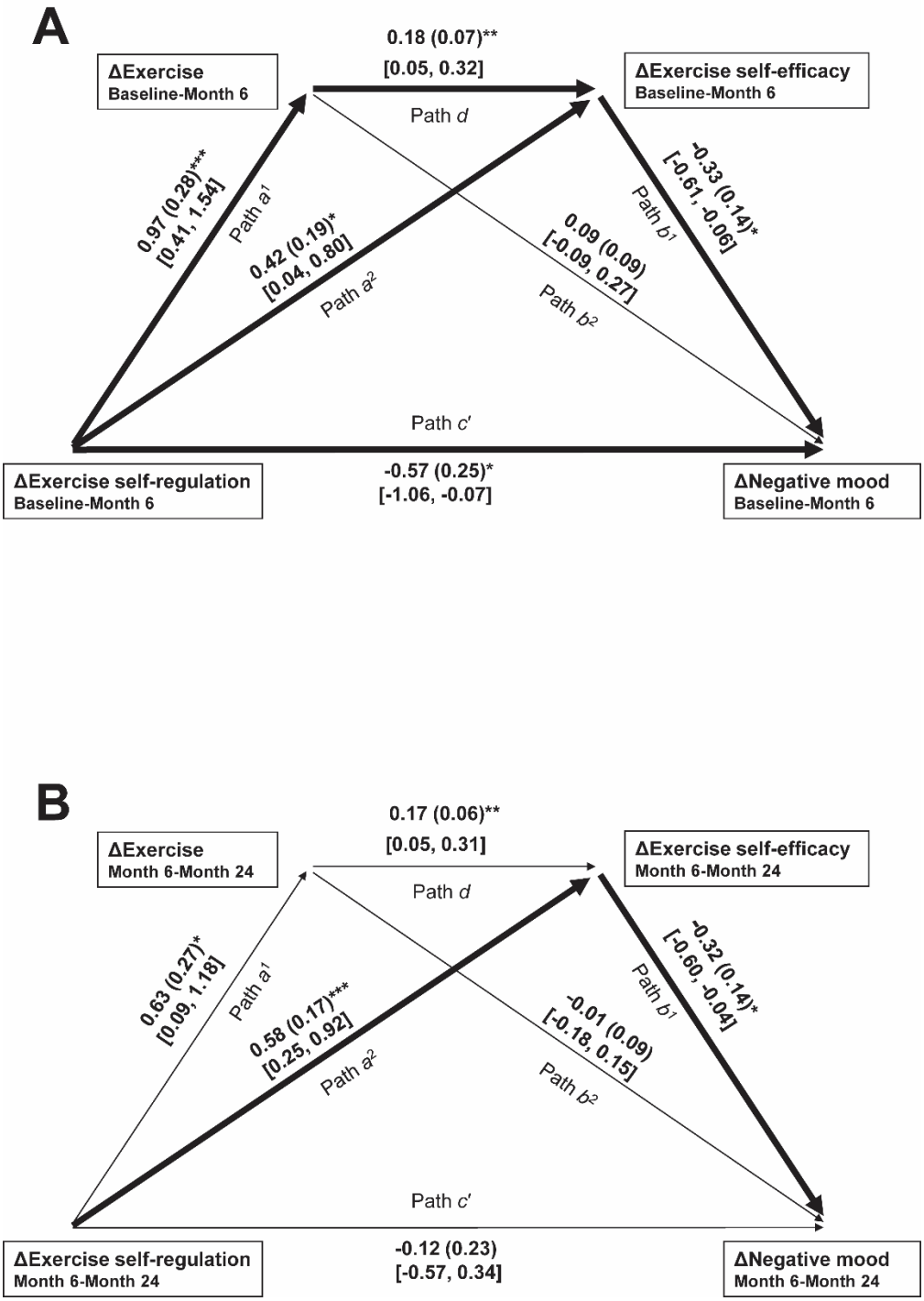

Figure 1. Serial multiple mediation results of the prediction of changes in negative mood by exercise self-regulation change through sequential changes in exercise then exercise self-efficacy from baseline–month 6 (A) and month 6–month 24 (B).
Note. $N = 87$. Δ = score change during the designated period. Path coefficients are given as B (SE_B) [95% confidence interval]. Heavy lines indicate significant paths toward change in the dependent variable of negative mood. *$p \leq .05$. **$p \leq .01$. ***$p \leq .001$ (two-tailed tests).

Discussion

Although significant within-group changes in the study variables were found, to increase confidence in the findings, assess generalizability, and better control for social support and expectation effects, replications with usual-care comparison conditions and various sample types are required. This brief report was intended to be preliminary in that regard. Further research will also be needed to identify and prioritize the "active ingredients" of the treatment (Annesi, 2020; MacLean et al., 2015). A study strength, however, were analyses of the dynamic psychosocial changes that occur across both weight-loss and weight-loss maintenance phases (Annesi, 2020; MacLean et al., 2015).

Findings suggested that extending the present research foci on changes in exercise-associated mood and its behavioral and psychosocial correlates (Arent et al., 2020) would be productive. This was signaled within the regression analyses because: (a) exercise-related self-efficacy, rather than exercise itself, emerged as a salient predictor of mood improvement; (b) self-regulation increases appeared to act upon self-efficacy as predicted (i.e., to increase when newly learned methods of self-management affects perceptions of ability/mastery for maintained behavioral change); and (c) changes in mood and emotional eating possessed strong enough relationships to affect both weight loss and its maintenance/regain. The present findings extended previous related research (Annesi & Eberly, 2022) by better-accounting for self-regulation processes and other psychological changes occurring beyond the phase of expected weight loss. It also clarified tentative relations within a causal chain model (Annesi, 2020) concerning the role of emotional eating on associations of exercise with short- and long-term weight loss through psychosocial, rather than energy-expenditure, pathways.

In addition to a lack of a control condition, limitations such as reliance on self-reports within a field setting that challenged internal validity were present. Nevertheless, findings from the present sample of women with obesity indicated important areas of treatment foci based on identified psychological mechanisms of the exercise treatment-mood change relationship as well as directions for future, more comprehensive, investigations that could further inform obesity-treatment theory and curricula.

Implications for Health Behavior Research

As theory-driven research improves comprehension of the dynamics of protocol-based behavioral treatments for obesity, better accounting for variables such as self-regulation, self-efficacy, mood, emotional eating – and effects associated with exercise amounts that can readily be maintained – can better direct advancements in behavioral interventions for the many adults in need of health-risk reductions. Researchers should seek to creatively incorporate theory in such a manner where findings can be readily incorporated into largescale, efficient applications.

Discussion Question(s)

1. To what extent does exercise-related self-regulation and self-efficacy play into the effects of exercise on mood within a behavioral obesity treatment?

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