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Keywords

obesity, weight loss, treatment, women, mood, body image

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Abstract

Physical activity could be associated with psychosocial correlates of changes in eating behaviors required for weight loss. This field investigation assessed relationships of physical activity with early changes in psychosocial variables such as depression, fatigue, and body satisfaction; and their effect on fruit/vegetable and sweets intake and weight change. Emerging adult women from a university setting ($M_{\text{age}} = 20.4$ years, $SD = 2.0$; $n = 36$) and adult women from a community health-promotion setting ($M_{\text{age}} = 45.6$ years, $SD = 7.3$; $n = 36$), participating in the same cognitive-behavioral weight-loss program that initiated physical activity prior to nutrition changes, were first contrasted on measures of physical activity, psychosocial changes, eating changes, and weight; then on their theory-based interrelations. The emerging adult women had significantly higher baseline scores on depression and physical activity, and significantly lower scores on fruit/vegetable intake. Improvements over 3 months in the psychosocial and behavioral variables and weight were significant, but did not significantly differ by group. Weight loss means were -3.89 kg and -4.16 kg, respectively. Using aggregated data, serial mediation analyses identified a significant path from change in physical activity, to change in depression, to change in intake of sweets, to change in weight. Paths were also significant when improvement in tension and fatigue was entered as the psychosocial variable. Age group did not moderate those relationships. Findings improved understandings of age effects, and interrelations of psychosocial and behavioral predictors of short-term weight loss that could help longer-term treatment targets.

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The prevalence of obesity in the United States has risen to 37% of women 20-39 years of age, and 45% of 40-50-year-olds (Flegal, Kruszon-Moran, Carroll, Fryar, & Ogden, 2014). Because of its association with health risks such as heart disease, type 2 diabetes, hypertension, dyslipidemia, and certain cancers, obesity is considered a major public health concern (Afshin et al., 2017). Non-surgical and non-pharmacological weight-loss treatments have most frequently been atheoretical, and have relied on advising participants about eating differently (Prestwich et al., 2014). Nearly all have been unsuccessful at reducing health risks (MacLean et al., 2015; Mann et al., 2007).

Early weight loss is needed to foster sufficient persistence with improvements in one's eating behaviors which, along with physical activity, is required for longer-term reductions in weight (Astrup & Rössner, 2000; Elfhag & Rössner, 2005). Thus, a better understanding of treatment-associated effects on psychosocial factors such as depression, fatigue, and body image during those initial weeks and months is crucial for guiding refinements of architectures that might reliably "set the stage" for long-term success (Palmeira et al., 2010). Particularly in women, emotions and satisfaction with one's body can have associations with eating behaviors and weight (Geliebter & Aversa, 2003; Palmeira et al., 2010). However, this might vary by age

(Grogan, 2006). For example, depression is associated with obesity (Pratt & Brody, 2014), and occurs more frequently in younger adults who might feel dejected based on their perceptions of life prospects and lack of social connections (Twenge, Cooper, Joiner, Duffy, & Binau, 2019). Body image, and its early changes associated with weight-loss efforts, might also vary by age and gender based on differing societal and peer expectations for a trim body (Grogan, 2006; Tiggemann, 2004). Since emerging adults 18–25 years old are highly sensitive to negative emotional stimuli and are undergoing considerable changes in their cognitive capacities and strategies (Tanner & Arnett, 2009), psychosocial factors in the milieu of attempting to control weight might have different implications for adults older than 25 years of age.

Physical activity is the strongest correlate of success with weight loss (Fogelholm & Kukkomen-Harjula, 2000). This might be due to associated effects of psychological changes on eating rather than energy expenditures that are minimal in deconditioned individuals (Annesi, 2012; Donnelly et al., 2009). Troiano et al. (2009) found that only 3% of women in the United States of ages 20–59 years obtained even the minimum amount of physical activity required for health improvements, and dropout from new exercise programs can be extreme in the first several months (Annesi, Unruh, Marti, Gorjala, & Tennant, 2011). Thus, early behavioral support of physical activity has been identified as an important component of weight-loss treatments requiring investigation (MacLean et al., 2015; Mann et al., 2007).

As proposed by social cognitive theory (Bandura, 1986) and self-efficacy theory (Bandura, 1997), mood is thought to play an important role both resulting from early changes in health behaviors and in facilitating subsequent and ongoing health-behavior changes (e.g., through feelings of ability [self-efficacy]). Bandura (1998) stated that people, "… rely on their somatic and emotional states in judging their capabilities" (p. 626). Bandurian theory also supports an association between self-evaluation of the body (i.e., as reflected through anticipated social expectations/judgements) and behavior change. Accordingly, he indicated that behavior is partially regulated by aroused social reactions (Bandura, 2004). Although reciprocal relationships between behaviors such as physical activity and healthy eating were found, several studies suggested that relationships are strongest when physical activity changes precede eating changes (Annesi, 2012). Ensuing from the above theory, previous research, and the directionality of relationships just suggested, Baker and Brownell (2000) proposed a path where physical activity/exercise leads to healthier eating and weight loss *through* improved psychosocial factors such as mood and body image. Their posited relationships are shown below:

Increased physical activity → Improved mood/body image → Improved eating behaviors → Reduced weight

Although relationships between (a) increased physical activity and improvements in mood and body image, and (b) mood/body image and eating behaviors have received support (Annesi, 2000, 2012; Palmeira et al., 2010; Teixeira et al., 2015; Trost, Owen, Bauman, Sallis, & Brown, 2002), the validity of the above-illustrated path has not been comprehensively tested. A treatment where physical activity is implemented and supported to maximize known challenges to its adherence (MacLean et al., 2015), prior to employing methods to change eating behaviors, would allow the temporal aspects and directionality of the suggested path to be addressed. Such findings could have implications for both weight-loss theory and intervention.

Although optimal practice should ground treatments in sound theory, evaluate their effects, and then decompose findings to determine their bases (Baranowski, Cerin, & Baranowski, 2009; Baranowski, Lin, Wetter, Resnicow, & Hearn, 1997; Rothman, 2004), such scientific rigor has rarely been implemented in the health behavior-change arena. Even when

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mediators of weight-loss treatment effects have been researched, the corresponding studies often relied on cross-sectional data that failed to account for the dynamics associated with weight-change processes, infrequently assessed mediation using accepted analytical standards, did not adequately account for mood changes associated with physical activity (Landers & Arent, 2012; Teixeira et al., 2015), and failed to consider the contexts of specific samples and conditions (Burke, Joseph, Pasick, & Barker, 2009).

Thus, the cognitive-behavioral treatment used within this research incorporated key tenets of social cognitive and self-efficacy theories (Bandura, 1986, 1997) applied to samples of adult and emerging adult women with obesity to facilitate testing of group differences in key psychological and behavioral measures. Assessment of relationships among those variables based on the previously suggested path by Baker and Brownell (2000) was also enabled. For example, self-regulatory skills targeting both physical activity and eating behaviors were focused upon within the intervention to induce behavioral improvements (e.g., enabling control over one's environment as exemplified in social cognitive theory). Participants' attribution of those learned skills for overcoming common barriers such as discomfort and slower-than-desired progress was intended to increase their self-efficacy, and adherence to the behavioral changes (e.g., fostering mastery experiences as exemplified in self-efficacy theory). Because the possible roles of mood and body satisfaction alterations had not been sufficiently addressed as correlates of required behavioral changes within such a treatment context, the present research was conducted to address those gaps through the inclusion of women of different age groups.

Research questions were as follows:

1. Do the psychosocial factors of tension, depression, fatigue, anger, confusion, vigor, and body satisfaction; the behavioral factors of fruit/vegetable intake, consumption of sweets, and completion of physical activity; and weight significantly differ either at baseline or over 3 months, between the tested age groups?
2. Was the 3-month change in weight significantly accounted for by a path from physical activity change, to (above-named) psychosocial changes, to (above-named) eating changes, to weight change?
3. Considering significant individual paths within the above-proposed models, was age group a significant moderator of those relationships?

Method

Participants

Women volunteered to participate in a weight-loss trial that emphasized physical activity and healthy eating. Enrollment was conducted separately within a large public university and a community health-promotion organization in the southeast United States. Inclusion criteria were a body mass index (BMI) of at least 30 kg/m^2 (obesity), not presently participating in any weight-loss program, and no known contraindications for study participation. Based on the aims of this research, ages of the university-based participants ranged from 18–25 years (emerging adults; M_{age} = 20.4 years, SD = 2.0; n = 36), and ages of the community health-promotion organization-based participants ranged from 25–50 years (adults; M_{age} = 45.6 years, SD = 7.3; n = 36). Although typical eating environments naturally differed by age group, all participants reported regular access to all types of foods (healthy and unhealthy). Independent t and χ^2 tests indicated no significant difference between the groups on baseline BMI ($M_{overall}$ = 35.1 kg/m^2, *SD* = 3.6) or ethnicity (overall 53% white, 44% black, 3% other). Institutional review board (IRB) approval was obtained, and written IRB-approved informed consent was received from all participants prior to study initiation.

Measures

Behavioral measures. Participants' daily intake of (a) fruits (e.g., small peach or apple [or 118 mL canned]), (b) vegetables (e.g., 118 mL carrots or peas), and (c) sweets (e.g., small piece of cake [59 mL] or candy [30 mL]) was recalled from the previous 7 days utilizing portion sizes presented by the U.S. Department of Agriculture (2017). The intake of fruits and vegetables was summed. In previous studies, test-retest reliabilities over 3 weeks ranged from .77–.83, and concurrent validity was indicated through significant correspondences with highly validated food-recall surveys (Block et al., 1986; Mares-Perlman et al., 1993). In previous research, fruit/vegetable intake was deemed a strong correlate of the overall healthfulness of the diet (Rolls, Ello-Martin, & Tohill, 2004). The intake of sweets was judged unhealthy because of its high energy density, low nutrient value, and association with risk for obesity (Te Morenga, Mallard, & Mann, 2012).

Using the Leisure-Time Physical Activity Questionnaire (Godin, 2011; Godin & Shephard, 1985), participants recalled each physical activity/exercise bout of at least 15 minutes, completed over the previous 7 days, based on their corresponding intensities. Possible intensities ranged from 3 metabolic equivalents (MET = O_2/kg/hour; Jetté, Sidney, & Blumchen, 1990) for "mild exercise/minimal exertion" (e.g., easy walking) to 9 METs for "strenuous exercise/heart beats rapidly" (e.g., running and vigorous swimming). The MET scores were summed. In previous studies, test-retest reliability over 2 weeks was .74, and concurrent and predictive validities were indicated through significant correspondences between Leisure-Time Physical Activity Questionnaire scores and accelerometer and maximal oxygen uptake (i.e., treadmill test) results (Godin, 2011; Godin & Shephard, 1985; Jacobs, Ainsworth, Hartman, & Leon, 1993; Miller, Freedson, & Kline, 1994).

Psychosocial measures. The tension-anxiety, depression-dejection, fatigue-inertia, anger-hostility, confusion-bewilderment, and vigor-activity scales of the Profile of Mood States-B (McNair & Heuchert, 2009) (hereafter, referred to as the first word in each scale's name) each had five, one- to three-word items (e.g., "anxious," "gloomy," "sluggish") consistent with its proposed dimensions of mood. Each participant recalled her "feelings over the past two weeks, including today" with possible responses ranging from 0 (*Not at all*) to 4 (*Extremely*). Scores for each scale were individually summed. Internal consistencies for women were Cronbach's αs = .84–.93, and test-retest reliabilities over a mean of 3 weeks averaged .69 (McNair & Heuchert, 2009). For the present sample, internal consistencies averaged Cronbach's α = .86. Research (McNair, Lorr, & Droppleman, 1992) suggested concurrent validity through correspondences between Profile of Mood States scale scores, and scores on well-validated corresponding measures.

The body areas satisfaction scale of the Multidimensional Body-Self Relations Questionnaire measured each participant's present degree of happiness/unhappiness with nine areas of her body (e.g., "lower torso [buttocks, hips, thighs, legs]", "mid torso [waist, stomach]") (Cash, 2000). Possible responses ranging from 1 (*Very dissatisfied*) to 5 (*Very satisfied*) were summed, then divided by 9. The internal consistency for women was Cronbach's α = .73, and test-retest reliability over 4 weeks was .74 (Cash, 2000). For the present sample, the internal consistency was Cronbach's $\alpha = .79$. Research suggested concurrent validity through correspondences between body areas satisfaction scale scores, and scores on other well-validated measures of body image (Rusticus & Hubley, 2005).

Weight. Body weight was measured in kg using a recently calibrated digital scale. After heavy outer-clothing such as a coat and shoes were removed, the mean of two consecutive measurements was recorded for each participant.

Procedure

Trained and certified wellness educators administered both treatment components. All participants first received physical activity support that included four, 45-minute one-on-one sessions over the 3-month study based on The Coach Approach protocol (Annesi et al., 2011), starting at baseline. In each session, participants learned and rehearsed one or two new self-regulatory skills (e.g., relapse prevention, cognitive restructuring) intended to counter barriers to adherence to physical activity. Individualized proximal goals were discussed, revised, and documented during each session. A behavioral contract was developed, and then revised during each session. Physical activity plans were adjusted so that before- to after-session changes yielded increased feelings of revitalization, which is consistent with adherence (Annesi, 2005). Physical activity types were based on participant preference.

Six weeks after the first physical activity support session, each participant started to record her daily energy intake for 2 weeks, was assigned a daily kilocalorie (kcal) limit based on current weight (e.g., 1500 kcal/day limit for a weight of 79–99 kg), and started biweekly group nutrition sessions. In each of the 60-minute nutrition sessions, participants received instructions in observing satiety levels in the context of when to eat, and practiced applying the acquired physical activity-related self-regulation skills to controlling eating. There was an emphasis placed on increasing fruit/vegetable intake and minimizing sweets.

The above two-component treatment, that sought to build self-efficacy through the development of self-regulatory skills and improved (physical activity-induced) psychological states countering barriers to persistence and goal attainment, was based on key tenets of social cognitive theory (Bandura, 1986, 2005), self-efficacy theory (Bandura, 1997), and self-regulation theory (Baumeister, Vohs, & Tice, 2007). Study staff administered all measures in a private area just prior to treatment start (baseline), and again at Month 3. Structured fidelity checks on approximately 15% of treatment sessions were conducted by study staff with the few protocol deviations identified and corrected.

Data Analyses

Because the suggested criteria for no systematic bias (White, Horton, Carpenter, & Pocock, 2011) were met (e.g., participants with missing data did not significantly differ from those without missing data on any demographic or baseline measure), use of the expectation maximization algorithm (Schafer & Graham, 2002) was justified for imputation of the 13% of missing cases (all from Month 3). This enabled the desired intention-to-treat format. For the primary regression analyses, an overall sample size of at least 68 participants was required to detect a moderate effect of $f^2 = .15$ at the statistical power of .80 ($\alpha < .05$) (Cohen, Cohen, West,

& Aiken, 2003). Gain scores were unadjusted for their baseline values (Glymour, Weuve, Berkman, Kawachi, & Robins, 2005). SPSS Statistics Version 22 (IBM, Armonk, NY) was used for the statistical analyses, incorporating the PROCESS macroinstruction application Model 6 (serial multiple mediation analysis), Model 3 (mediation analysis), and Model 1 (moderation analysis) (Hayes, 2013, 2015). Each included 20,000 bias-corrected and accelerated bootstrap resamples. Variance inflation factors scores of 1.01–1.43 indicated acceptable collinearity in the data. Statistical significance for between- and within-group contrasts were set at $\alpha < .05$ (two-tailed). Because directionality of relationships between changes in the present variables was previously established in women (Annesi, 2000), statistical significance was set at $\alpha < .05$ (one-tailed) for the planned regression analyses.

Independent *t* tests first assessed group differences at baseline. Dependent *t* tests and mixed-model repeated-measures ANOVAs then assessed within-group score changes from baseline–Month 3, and between-group differences in those changes. Effect sizes for the *t* tests were computed as Cohen's *d* ($M_{\text{Group 1}}$-$M_{\text{Group 2}}$ /SD_{pooled}, and $M_{\text{Month 3}}$-M_{baseline}/SD_{baseline}, respectively); and for the time × group ANOVAs as partial eta-squared ($\eta^2_{\text{partial}} = SS_{\text{effect}}/[SS_{\text{effect}}+SS_{\text{error}}]$) (Fritz, Morris, & Richler, 2012). Small, moderate, and large effects are, respectively, .20, .50, .80 for the *t* tests; and .06, .14, and .20 for the ANOVAs. Additional *t* tests contrasted group means with corresponding age-specific normative data of women on the psychosocial measures using the following formula: $t = M_{\text{sample}}\text{-}M_{\text{norm}}/(\sqrt{SD_{\text{sample}}/n_{\text{sample}}})$
The corresponding effect size was calculated as $d = M_{\text{sample}}\text{-}M_{\text{norm}}/SD_{\text{sample}}$

Serial multiple mediation models were then fit where change in physical activity was the independent variable, changes in one of the assessed psychosocial variables and eating measures were (correspondingly ordered) mediators, and change in weight was the dependent variable (Figure 1). Consistent with recent suggestions (Hayes, 2013, 2015), statistical significance of the total effect of the independent variable on the dependent variable was not considered in the analysis plan. Finally, moderation of any significant path within the serial multiple mediation models by group was assessed.

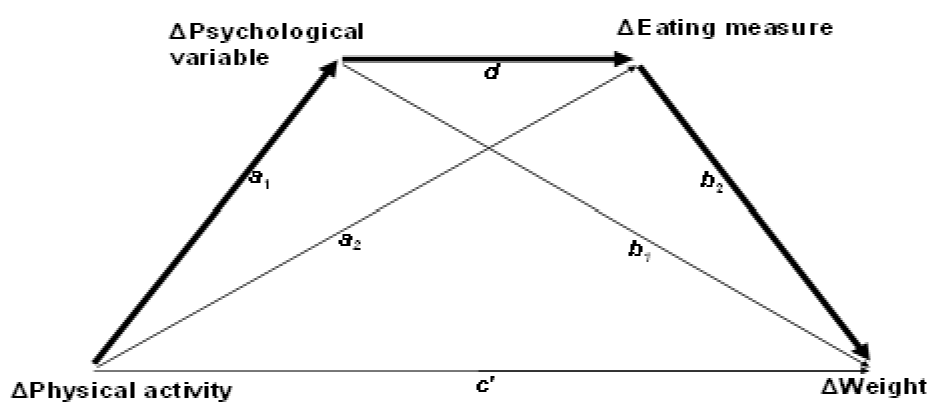

Figure 1. Relationships within the serial multiple mediation models (the hypothesized path is presented in bold).

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Results

Between-group Contrasts

Scores at baseline, Month 3, and change from baseline–Month 3 are presented in Table 1. At baseline, the emerging adult group had significantly greater depression, $t(70) = 2.14$, $p = .036$, $d = 0.27$, 95% CI [0.13, 3.65], and physical activity, $t(70) = 3.30$, $p = .002$, $d = 0.79$, 95% CI [2.60, 10.54], scores than the adult group. The adult group had a significantly greater intake of fruits/vegetables at baseline, $t(70) = 2.09$, $p = .040$, $d = 0.50$, 95% CI [0.04, 1.90]. With the exception of change in anger scores in the emerging adult group, all assessed psychosocial, behavioral, and weight variables significantly improved from baseline–Month 3 (Table 1). There was no significant time × group difference for any assessed variable, *p*s > .09, $\eta^2_{partial}$ values < .04.

Contrasts with Normative Data

Within the emerging adult group, baseline fatigue and confusion scores were significantly higher than corresponding age normative scores (McNair & Heuchert, 2009), $M_{normative} = 4.92$, $t(35) = 5.06$, $p < .001$, $d = 0.84$, 95% CI [2.63, 6.15], and $M_{normative} = 5.38$, $t(35) = 3.80$, $p < .001$, $d = 0.63$, 95% CI [1.18, 3.90], respectively; and significantly lower on body areas satisfaction than the normative score (Cash, 2000), $M_{normative} = 3.36$, $t(35) = 23.55$, $p < .001$, $d = 3.92$, 95% CI [-2.26, -1.90]. Within the adult group, baseline fatigue and confusion scores were also significantly higher than corresponding age normative scores (McNair & Heuchert, 2009), $M_{normative} = 4.00$, $t(35) = 7.08$, $p < .001$, $d = 1.18$, 95% CI [4.10, 7.40], and $M_{normative} = 2.67$, $t(35) = 8.93$, $p < .001$, $d = 1.49$, 95% CI [3.82, 6.06], respectively; and significantly lower on vigor and body areas satisfaction than the normative scores (Cash, 2000; McNair & Heuchert, 2009), $M_{normative} = 8.69$, $t(35) = 2.14$, $p = .039$, $d = 0.36$, 95% CI [-2.96, -0.08], and $M_{normative} = 3.36$, $t(35) = 32.71$, $p < .001$, $d = 7.48$, 95% CI [-2.43, -2.15], respectively.

Paths Predicting Weight Loss

Bivariate intercorrelations of possible predictors of 3-month weight change (Δ) are given in Table 2. A significant serial mediation path from physical activity change, to psychosocial change, to sweets change, to weight change was present in the following: Δphysical activity→Δdepression→Δsweets→Δweight, $B = -.002$, $SE_B = .002$, 95% CI [-0.0090, -0.0001]; Δphysical activity→Δtension→Δsweets→Δweight, $B = -.002$, $SE_B = .003$, 95% CI [-0.0105, -0.0001]; and Δphysical activity→Δfatigue→Δsweets→Δweight, $B = -.005$, $SE_B = .004$, 95% CI [-0.0156, -0.0009]. Additional significant paths to weight change within the models were: Δphysical activity→Δdepression→ Δweight, $B = -.009$, $SE_B = .009$, 95% CI [-0.0311, -0.0001]; Δphysical activity→Δtension→Δweight, $B = -.010$, $SE_B = .007$, 95% CI [-0.0246, -0.0016]; and Δphysical activity→Δsweets→Δweight, $B = -.008$, $SE_B = .008$, 95% CI [-0.0265, -0.0002]. No serial mediation path incorporating fruit/vegetable change was significant. Only two redundant paths from the above models including sweets change were significant, Δphysical activity→Δdepression→Δweight, $B = -.012$, $SE_B = .011$, 95% CI [-0.0396, -0.0007]; Δphysical activity→Δtension→Δweight, $B = -.012$, $SE_B = .008$, 95% CI [-0.0285, -0.0026]. *B* coefficients for model paths are given in Table 3. Group did not significantly moderate any of the individual paths within the assessed models.

Table 1

Within-group Changes in Study Variables

	Baseline		Month 3		Score change		*t*	*p*	95% CI	*d*
	M	*SD*	*M*	*SD*	*M*	*SD*				
Tension										
Emerging adult	6.01	4.02	3.08	3.23	-2.93	4.03	4.36	<.001	-4.29, -1.57	0.73
Adult	4.94	3.97	2.75	2.60	-2.19	3.62	3.64	.001	-3.42, -0.97	0.55
Aggregated	5.48	4.00	2.92	2.92	-2.56	3.82	5.69	<.001	-3.46, -1.66	0.64
Depression										
Emerging adult	6.11	3.87	3.83	3.55	-2.28	4.66	3.86	.006	-3.86, -0.70	0.59
Adult	4.22	3.61	2.39	2.74	-1.83	3.07	3.59	.001	-2.87, -0.80	0.50
Aggregated	5.17	3.83	3.11	3.23	-2.06	3.93	4.44	<.001	-2.98, -1.13	0.54
Fatigue										
Emerging adult	9.31	5.21	5.81	4.85	-3.50	6.18	3.40	.002	-5.59, -1.41	0.67
Adult	9.75	4.87	4.78	3.51	-4.97	4.72	6.32	<.001	-6.57, -3.38	1.02
Aggregated	9.53	5.01	5.29	4.23	-4.24	5.51	6.53	<.001	-5.53, -2.94	0.85
Anger										
Emerging adult	4.67	4.06	3.19	3.59	-1.47	4.97	1.78	.084	-3.15, 0.21	0.36
Adult	4.64	3.12	2.89	2.86	-1.75	2.95	3.56	.001	-2.75, -0.75	0.56
Aggregated	4.65	3.60	3.04	3.23	-1.61	4.06	3.37	.001	-2.56, -0.66	0.45
Confusion										
Emerging adult	7.92	4.01	6.14	3.98	-1.78	3.67	2.90	.006	-3.02, -0.54	0.44
Adult	7.61	3.32	6.32	2.15	-1.29	2.82	2.74	.010	-2.25, -0.34	0.39
Aggregated	7.76	3.66	6.23	2.58	-1.53	3.26	3.99	<.001	-2.30, -0.77	0.42
Vigor										
Emerging adult	6.22	3.97	9.36	4.86	3.14	4.76	3.95	<.001	1.53, 4.75	0.49
Adult	7.17	4.26	11.42	5.38	4.25	5.11	4.99	<.001	2.52, 5.98	1.00
Aggregated	6.69	4.12	10.39	5.20	3.69	4.94	6.35	<.001	2.53, 4.85	0.90
Body areas satisfaction										
Emerging adult	1.28	0.53	1.52	0.67	0.23	0.60	2.33	.026	0.03, 0.44	0.44
Adult	1.07	0.42	1.62	0.96	0.55	0.93	3.54	.001	0.23, 0.87	1.31
Aggregated	1.18	0.49	1.57	0.82	0.39	0.80	4.18	<.001	0.21, 0.58	0.80
Fruit/vegetable intake (portions/day)										
Emerging adult	2.89	1.63	4.49	2.16	1.60	1.87	5.12	<.001	0.96, 2.23	0.98
Adult	3.86	2.26	5.61	2.67	1.75	2.24	4.69	<.001	0.99, 2.51	0.77
Aggregated	3.38	2.02	5.05	2.48	1.67	2.05	6.93	<.001	1.19, 2.16	0.83
Sweets intake (portions/day)										
Emerging adult	2.38	1.79	1.07	0.92	-1.31	1.79	4.39	<.001	-1.91, -0.70	0.73
Adult	2.22	1.88	1.44	1.00	-0.78	1.44	3.25	.001	-1.26, -0.29	0.41
Aggregated	2.30	1.82	1.26	0.97	-1.04	1.63	5.42	<.001	-1.42, -0.66	0.57
Physical activity (METs/week)										
Emerging adult	14.99	9.82	33.76	16.46	18.78	16.98	6.64	<.001	13.03, 24.52	1.91
Adult	8.42	6.78	29.96	13.46	21.54	13.96	9.26	<.001	16.82, 26.27	3.18
Aggregated	11.70	9.01	31.86	15.05	20.16	15.50	11.04	<.001	16.52, 20.16	2.34
Weight (kg)										
Emerging adult	96.30	13.85	93.90	13.00	-2.39	4.42	3.25	.003	-3.89, -0.90	0.17
Adult	94.15	11.47	90.88	11.86	-3.27	2.61	7.53	<.001	-4.16, -2.39	0.29
Aggregated	95.22	12.67	92.39	12.45	-2.83	3.63	6.63	<.001	-3.69, -1.98	0.22

Note. Emerging adult group $n = 36$ ($df = 35$). Adult group $n = 36$ ($df = 35$). Aggregated data $N = 72$ ($df = 71$). Score change = Month 3 - baseline. 95% CI = 95% confidence interval. d = Cohen's measure of within-group change effect ($M_{\text{Month 3}}$ - $M_{\text{baseline}}/SD_{\text{baseline}}$).

Table 2

Bivariate Intercorrelations of Possible Predictors of Weight Change

	1	2	3	4	5	6	7	8	9	10
1. ΔTension	…	.25*	.49***	.36**	.34**	-.21*	-.43***	-.11	.23*	-.23*
2. ΔDepression		…	.44***	.30**	.23*	-.31**	-.10	-.18	.25*	-.24*
3. ΔFatigue			…	.48***	.47***	-.38**	-.28**	-.22*	.31**	-.31**
4. ΔAnger				…	.21*	-.11	-.05	-.05	.18	-.06
5. ΔConfusion					…	-.15	-.22*	-.02	.15	.04
6. ΔVigor						…	.37**	.16	-.03	.46***
7. ΔBody areas satisfaction							…	.11	-.01	.13
8. ΔFruit/vegetable intake								…	-.17	.28**
9. ΔSweets intake									…	-.13
10. ΔPhysical activity										…

Note. The Delta symbol (Δ) denotes change from baseline to Month 3.
**p* < .05, ***p* < .01, ****p* < .001 (one-tailed test).

Post Hoc Test

Because depression score at baseline significantly differed by age group, an exploratory analysis was conducted to determine whether body areas satisfaction score significantly mediated the prediction of depression by group. For that model ($\alpha < .05$, two-tailed; Figure 2), significant mediation was found, $B = .683$, $SE_B = .418$, 95% CI [0.0067, 1.6500].

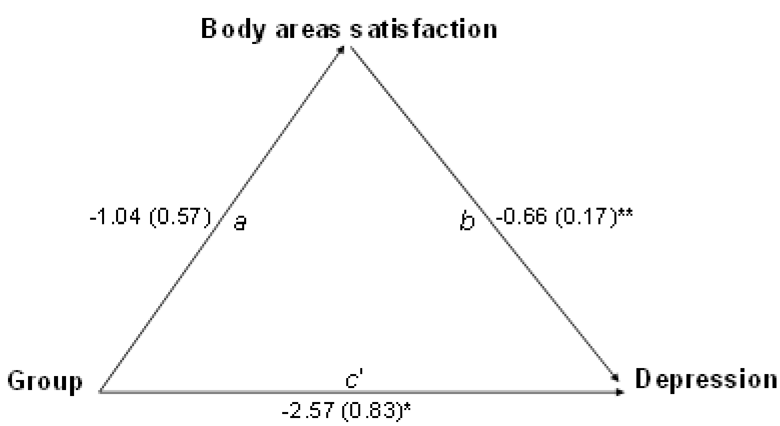

Figure 2. Body areas satisfaction as a mediator of the prediction of depression by group
*p < .05. **p < .01.

Table 3

Results of Serial Multiple Mediation Analyses (N=72)

Independent variable	Mediator 1	Mediator 2	Dependent variable	Path a_1 B (SE_B)	Path a_2 B (SE_B)	Path b_1 B (SE_B)	Path b_2 B (SE_B)	Path c' B (SE_B)	Path d B (SE_B)
ΔPhysical activity	ΔTension	ΔSweets	ΔWeight	-.06 (.03)*	-.01 (.01)	.07 (.11)	.44 (.27)*	.02 (.03)	.08 (.05)
ΔPhysical activity	ΔDepression	ΔSweets	ΔWeight	-.06 (.03)*	-.01 (.01)	.15 (.11)	.45 (.26)*	.02 (.03)	.07 (.05)
ΔPhysical activity	ΔFatigue	ΔSweets	ΔWeight	-.11 (.04)**	-.01 (.01)	.01 (.09)	.51 (.28)*	.01 (.03)	.09 (.04)**
ΔPhysical activity	ΔAnger	ΔSweets	ΔWeight	-.02 (.03)	-.01 (.01)	.00 (.11)	.52 (.27)*	.01 (.03)	.07 (.05)
ΔPhysical activity	ΔConfusion	ΔSweets	ΔWeight	.01 (.03)	-.01 (.01)	.11 (.13)	.49 (.27)*	.01 (.03)	.08 (.06)
ΔPhysical activity	ΔVigor	ΔSweets	ΔWeight	.14 (.03)***	-.01 (.01)	-.15 (.10)	.53 (.26)*	.03 (.03)	.01 (.04)
ΔPhysical activity	ΔBody areas satisfaction	ΔSweets	ΔWeight	.01 (.01)	-.01 (.01)	-1.41 (.52)**	.53 (.25)*	.02 (.03)	.03 (.25)
ΔPhysical activity	ΔTension	ΔFruits/ vegetables	ΔWeight	-.06 (.03)*	.05 (.02)***	.20 (.11)*	-.04 (.23)	.01 (.03)	-.01 (.06)
ΔPhysical activity	ΔDepression	ΔFruits/ vegetables	ΔWeight	-.06 (.03)*	.05 (.02)**	.20 (.11)*	-.01 (.23)	.01 (.03)	-.05 (.06)
ΔPhysical activity	ΔFatigue	ΔFruits/ vegetables	ΔWeight	-.11 (.04)**	.05 (.02)**	.05 (.08)	-.03 (.23)	.01 (.03)	-.04 (.04)
ΔPhysical activity	ΔAnger	ΔFruits/ vegetables	ΔWeight	-.02 (.03)	.05 (.01)***	.04 (.11)	-.04 (.23)	.00 (.03)	-.01 (.06)
ΔPhysical activity	ΔConfusion	ΔFruits/ vegetables	ΔWeight	.01 (.03)	.05 (.01)***	.15 (.13)	-.03 (.23)	.00 (.03)	-.02 (.07)
ΔPhysical activity	ΔVigor	ΔFruits/ vegetables	ΔWeight	.14 (.03)***	.05 (.02)**	-.14 (.10)	-.05 (.23)	.02 (.03)	-.01 (.05)
ΔPhysical activity	ΔBody areas satisfaction	ΔFruits/ vegetables	ΔWeight	.01 (.01)	.05 (.01)***	-1.40 (.53) **	-.01 (.22)	.01 (.03)	.14 (.29)

Note. Results for each model are based on separate 20,000 bias-corrected bootstrap resamples. The Delta symbol (Δ) denotes change from baseline to Month 3. Path a_1 = independent variable→mediator 1. Path a_2 = independent variable→mediator 2. Path b_1 = mediator 1→dependent variable. Path b_2 = mediator 2→dependent variable. Path c' = independent variable→dependent variable. Path d = mediator 1→mediator 2.
*$p < .05$, **$p < .01$, ***$p < .001$ (one-tailed test).

Discussion

Findings within this field investigation increased understandings of differences between emerging adult and adult women with obesity on mood and body satisfaction factors, and how changes in those psychosocial factors interact with eating behaviors to mediate the physical activity-weight loss relationship. The baseline differences of significantly more physical activity in the younger adult group, and fruit/vegetable intake significantly higher in the adult group, are consistent with studies across individuals' weight status (Serdula et al., 2004; Trost et al., 2002). In recent research, Twenge and colleagues (2019) posited that tendencies of higher depression scores in younger adults are attributable to their lack of in-person interactions in favor of electronic means of communications that can be impersonal, even hostile. Reduced sleep might also co-vary with a high usage of electronic communications devises into the night and further induce depressed feelings (Twenge et al., 2019). Additional reasons for this difference specifically in women with obesity are unknown, however the present post hoc analysis suggests that reduced satisfaction with one's body is a contributing factor. It is also possible, however, that depressed feelings induce poor body satisfaction.

Across age groups, the finding of fatigue being higher, and body satisfaction being lower, than normative values is indicative of how women with obesity have been thought to differ from the corresponding population as a whole (Schwartz & Brownell, 2004; Vgontzas, Bixler, & Chrousos, 2006). Because disparities in body image have been related to racial/ethnic differences (Molloy & Herzberger, 1998), extensions of this research should evaluate that finding according to age groups, and how outcomes within weight-loss treatments are affected. Replications should also assess whether fatigue and depression are related to an unwillingness to engage in physical activity and healthy eating and, thus, serve as impetus for the development of obesity. Although directed research would be required to confirm such, it is likely that a reciprocal relationship exists where high fatigue and depression induce lifestyle behaviors conducive to obesity, and obesity generates low energy and feelings of dejection and sadness. Although increases in physical activity associated with the validated exercise support process were considerable within this study (i.e., extremely large effect sizes averaging $d = 2.34$), associations between physical activity and mood improvements have also been found to be associated with only 2–3 sessions per week of walking (Annesi, 2000, 2012).

The present intervention that focused on establishing physical activity through the development of self-regulatory skills prior to adapting those skills to eating changes was associated with significant improvements in tension, depression, fatigue, anger, confusion, vigor, body satisfaction, fruit/vegetable intake, reduction of sweets intake, physical activity, and weight across groups. This supported its theory-based architecture applicable to field settings that is consistent with previous research (Annesi, 2012; Teixeira et al., 2015). Although trials using these methods suggest resilient effects, decomposition of their outcomes were heretofore incomplete. Within this study, the path of increased physical activity, to improvements in mood and body satisfaction, to improvements in eating behaviors, to weight loss proposed by Baker and Brownell (2000) was partially supported within the present samples. Namely, the prediction of reduced sweets (but not increase in fruits/vegetables) by reduced depression, tension, and fatigue scores (but not other hypothesized dimensions of mood or body satisfaction) served as significant mediators of the physical activity-weight loss relationship. Previous research on emotional eating has also suggested that mood improvements are more associated with a reduction in unhealthy food groups (e.g., sweets and fats) than an increase in healthy ones (e.g., fruits and vegetables) (Oliver, Wardle, & Gibson, 2000). Because the improvement in body areas satisfaction score was not a significant mediator within this study's serial multiple mediation analyses, future research might instead treat this variable as an outcome variable needed for persistence. For example, consistent with self-efficacy theory (Bandura, 1997), if improvements related to satisfaction with one's body are not precipitously attained, perseverance with weight-loss behaviors such as regular physical activity and healthy eating could suffer. Because age group did not significantly moderate the tested paths, implications for interventions were applicable across the assessed age groups in women.

Limitations of this research beyond challenges to internal validity inherent in field research such as expectation, experimenter, and social support effects should be acknowledged. For example, the volunteer nature of this and other weight-loss treatment studies might yield samples that are more motivated than the entire population of individuals with obesity. It is also possible that the rate of volunteerism could vary by age, which could have confounded the contrasts. Possibly, future studies could seek assertive referrals from physicians and other healthcare practitioners whereby less motivated individuals might increasingly become treatment participants. Future research should also clarify whether self-motivation inherently differs by age group, which might require accounting within intervention designs. Although the present age ranges and inclusion of only women was justified within this research, extensions should evaluate men, seniors, those with overweight and/or morbid obesity, and individuals with a medical disorder that might be affected by excess weight (e.g., type 2 diabetes, hypertension) to evaluate generalizability of findings. Even considering that early success with weight loss is essential for participants' persistence, much longer-term evaluations will be needed to assess lasting effects on health risks, quality-of-life, and morbidity. Finally, although the model-based path toward weight loss assessed in the present study was based on theory and the extant research, other paths should also be tested to examine the salience of additional established paradigms of behavior change (e.g., theory of planned behavior, transtheoretical model). However, given the promising results identified within this study, it is hoped that researchers continue incorporating the benefits of field-based designs (Green, Sim, & Breiner, 2013), better address experimental confounds, and extend this research to impact the many individuals with obesity.

Implications for Health Behavior Theory

Considerable utility was demonstrated across age groups in the present intervention model that focused on acquiring self-regulatory skills through physical activity prior to the facilitation of eating-behavior changes. This specialized use of cognitive-behaviorally supported physical activity successfully induced improvements in mood and body image, and thus should inform future behavioral treatments of obesity. Significant theoretical paths incorporating changes in the tested psychosocial variables in the prediction of weight loss were identified during the decomposition of effects. Given the identified role of depression, tension, and fatigue in reducing the unfavorable eating behavior within the analyses, additional treatment attention might target furthering their improvements in the future. For example, methods such as progressive relaxation and deep breathing might be embedded to reduce tension; and short walks throughout the day and healthy sleep habits might be advocated to further lessen fatigue. However, based on the present findings, it is good news for practitioners that significant effects will likely occur simply by facilitating regular physical activity that fosters self-regulation skills. If the rate of weight change within this study is maintained for even an additional 3 months with persistent positive changes in mood, body satisfaction, and eating behaviors, health behavior-change professionals will be newly empowered to disseminate a successful weight-management intervention model through community-based settings and facilitate a degree of success with weight loss that has been elusive.

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