3-30-2018

Effects of Treatment-Associated Increases in Fruit and Vegetable Intake on the Consumption of Other Food Groups and Weight Through Self-Regulatory Processes

James J. Annesi
Kennesaw State University, jannesi@kennesaw.edu

Effects of Treatment-Associated Increases in Fruit and Vegetable Intake on the Consumption of Other Food Groups and Weight Through Self-Regulatory Processes

James J Annesi, PhD, FAAHB, FTOS, FAPA

Perm J 2018;22:17-143

E-pub: 03/30/2018

https://doi.org/10.7812/TPP/17-143

ABSTRACT

Context: Increased intake of fruits and vegetables (FV) may be useful for weight loss.

Objective: This study was designed to evaluate the effects of changes in FV intake on the overall diet and to determine if self-regulation affects the association between changes in FV intake and weight.

Methods: Women with obesity (N = 74, mean age = 47.7 years) participating in a year-long behavioral weight-loss treatment were assessed regarding changes in consumption of various food groups, physical activity, and eating self-regulation over 6, 12, and 24 months.

Results: FV intake change significantly predicted changes in weight and consumption of dairy and bread products and sweets. The only other notable relationships were among changes in sweets, bread, and dairy consumption over 24 months. Over 6, 12, and 24 months, changes in self-regulation significantly mediated the FV intake-weight change relationship. The overall mediation models were significant (R^2 values = 0.19, 0.13, and 0.32, respectively). A reciprocal relationship between changes in FV intake and self-regulation also was found. Significant increases in physical activity outputs did not influence weight changes.

Conclusion: Findings supported a relationship between FV intake and weight loss occurring through self-regulatory skills. Associations between FV intake and reduced consumption of other food groups provided data useful for improving the architecture of behavioral weight-loss treatments and the foci of medical practitioners' helping methods.

INTRODUCTION

Obesity is a medical condition with considerable effects on health risks and quality of life. Although the popular focus on targeting proportions of diet macronutrients (ie, proteins, fats, and carbohydrates) for weight loss has proved ineffective,[1] fruit and vegetable (FV) intake has been associated with weight loss.[2,3] Although FV intake can influence consumption of other food groups,[1] this has been an understudied area. Targeting as few behavioral changes as possible may serve as a therapeutic advantage when designing weight-loss treatments.[4]

Because it takes considerable self-control to eat more healthy food and less unhealthy food such as sweets, self-regulation instruction has become a focus of behavioral weight-loss treatments that is based on accepted behavior-change theories such as social cognitive theory.[5,6] It is possible that the increased use of self-regulation methods (eg, goal setting/progress tracking, restructuring unproductive self-talk, environmental [stimulus] control) mediates the FV-weight loss relationship and, further, has a symbiotic, mutually reinforcing relationship with FV intake.

Women with obesity who participated in a community-based behavioral weight-loss program were assessed over 6, 12, and 24 months. It was expected that increased FV intake would be significantly associated with reduced weight and reduced consumption of other food groups. Investigators also predicted that the relationship between increased FV intake and reduced weight would be significantly mediated by treatment-associated changes in dietary self-regulation, and that relationships between changes in FV intake and self-regulation would be reciprocal.

METHODS

Participants

Participant (N = 74) data were derived from a longitudinal test of treatment-associated changes in emotional eating.[7] The volunteers were required to be at least age 21 years with a body mass index (BMI) of 30 kg/m^2 to 40 kg/m^2 and not be participating in a weight-loss program or taking a psychotropic medication. Women with physical contraindications to participation (such as pregnancy) also were excluded. The mean age was 47.7 years (standard deviation [SD] = 8.0), and the mean BMI was 34.9 kg/m^2 (SD = 3.2). The racial/ethnic makeup was approximately two-thirds white and one-third African American; several participants represented other racial categories. Nearly all were from households in the middle family income range of $50,000 to $100,000 yearly. University institutional review board approval and written informed consent were obtained.

Measures

Eating Behaviors

Daily servings of vegetables (eg, 118 mL [4 ounces] of peas); fruits (eg, 118 mL [4 ounces] of an orange); dairy products (eg, 236 mL [8 ounces] of yogurt); meats, beans, nuts, and other proteins (eg, 59 mL [2 ounces] of boneless chicken); bread products (eg, 59 mL [2 small slices] of whole-grain bread); and sweets (eg, 118 mL of a small brownie) as indicated by US Department of Agriculture sources[8] were summed using a brief survey. FV intake was then aggregated. Response scores demonstrated significant correspondences (β values = 0.45-0.83, all p values < 0.001) with

James J Annesi, PhD, FAAHB, FTOS, FAPA, is the Vice President of Research and Evaluation at the YMCA of Metropolitan Atlanta and PT Professor in the Department of Health Promotion and Physical Education at Kennesaw State University in GA. E-mail: jamesa@ymcaatlanta.org.

the scores of more comprehensive and extensively validated food frequency recalls, and test-retest reliabilities over 3 weeks ranged between 0.77 and 0.83.[9,10]

Eating Self-Regulation

To assess the use of self-regulation skills related to eating, responses to 10 items (1 = never to 5 = often) such as "I say positive things to myself about eating well" and "I keep a record of my eating" were summed.[11] The internal consistency was Cronbach $\alpha = 0.81$, and test-retest reliability over 2 weeks was 0.74.[11] For the data within this study, Cronbach $\alpha = 0.80$.

Physical Activity

The number of physical activity sessions per week of at least 15 minutes' duration was recalled using the Leisure-Time Physical Activity Questionnaire (Section 1).[12] Activity types corresponded to metabolic equivalents (MET) equating O_2/kg/hour ranging from 3 MET (eg, easy walking) to 9 MET (running) and were summed.[12] Previous research[13,14] found significant relationships (β values = 0.38-0.57, all p values < 0.001) between the Leisure-Time Physical Activity Questionnaire and accelerometer, weight change, and maximal oxygen uptake results. Test-retest reliability over 2 weeks was 0.74.[14]

Weight

Body weight was measured using a recently calibrated digital scale. The mean of two consecutive measurements was recorded (in kg) after removal of heavy outer clothing.

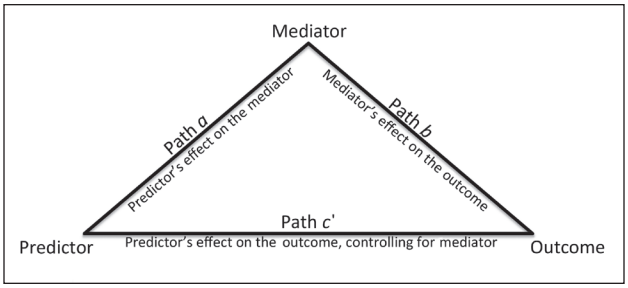

Figure 1. Mediation analyses diagram.

Procedure

The treatment consisted of components of physical activity support and eating-behavior change based on tenets of social cognitive theory,[5] especially the emphasis on use of self-regulatory skills to effectively deal with lifestyle barriers.[6] The treatment was administered by trained wellness staff members at a community wellness center.

The Coach Approach protocol[15] supported physical activity via six 45-minute 1-on-1 meetings. Assimilation of self-regulation methods such as goal setting, thought-stopping/cognitive restructuring, relapse prevention, dissociation, and stimulus control was the central focus. After 10 weeks of physical activity support alone, instruction in food logging was added, and group

Table 1. Descriptive statistics, change scores, and intercorrelations between changes in food group consumption and weight over 6, 12, and 24 months (N = 74)

Category	Baseline, mean (SD)	Assessment month, mean (SD)	ΔBaseline-assessment month, mean (SD)	Category intercorrelations					
				1	2	3	4	5	6
Assessment month 6									
1. Fruit/vegetable intake/d	3.73 (1.53)	5.65 (1.93)	1.92[a] (1.79)		-0.11	0.22	-0.26[b]	-0.28[b]	-0.28[b]
2. Dairy product intake/d	1.69 (1.02)	1.69 (0.93)	0.00 (1.09)			0.31[c]	0.22	0.21	0.06
3. Meat/protein intake/d	2.93 (0.98)	2.86 (1.16)	-0.33 (0.520)				0.00	-0.12	-0.13
4. Bread product intake/d	3.05 (1.50)	2.12 (1.17)	-0.93[a] (1.50					0.52[c]	0.18
5. Sweets intake/d	1.86 (1.14)	1.01 (1.03)	-0.86[a] (1.20)						0.17
6. Weight (kg)	94.77 (12.19)	88.77 (12.26)	-6.00[a] (4.87)						
Assessment month 12									
1. Fruit/vegetable intake/d	3.73 (1.53)	5.59 (2.01)	1.86[a] (1.880		-0.38[c]	0.17	-0.39[c]	-0.27[b]	-0.30[c]
2. Dairy product intake/d	1.69 (1.02)	1.65 (1.02)	-0.04 (1.10)			0.01	0.27[b]	0.21	0.17
3. Meat/protein intake/d	2.93 (0.98)	2.74 (0.93)	-0.18 (1.05)				0.08	0.01	-0.01
4. Bread product intake/d	3.05 (1.50)	2.01 (1.06)	-1.04[a] (1.53)					0.33[c]	0.13
5. Sweets intake/d	1.86 (1.14)	0.92 (0.78)	-0.94[a] (1.36)						0.09
6. Weight (kg)	94.77 (12.19)	89.30 (12.79)	-5.48[a] (5.97)						
Assessment month 24									
1. Fruit/vegetable intake/d	3.73 (1.53)	5.87 (2.07)	2.14[a] (2.08)		-0.31[c]	0.14	-0.34[c]	-0.24[b]	-0.51[c]
2. Dairy product intake/d	1.69 (1.02)	1.64 (0.98)	-0.05 (1.20)			0.03	0.23	0.27[b]	0.22
3. Meat/protein intake/d	2.93 (0.98)	2.83 (0.99)	-0.09 (1.21)				0.12	-0.08	0.04
4. Bread product intake/d	3.05 (1.50)	2.04 (1.35)	-1.01[a] (1.95)					0.34[c]	0.04
5. Sweets intake/d	1.86 (1.14)	1.09 (1.05)	-0.78[a] (1.51)						0.15
6. Weight (kg)	94.77 (12.19)	89.35 (12.6)	-5.43[a] (6.41)						

[a] $p < 0.001$.
[b] $p < 0.05$.
[c] $p < 0.01$.
SD = standard deviation.

nutrition sessions were held every 2 weeks using the Weight Loss For Life protocol.[16] Sessions adapted self-regulatory skills learned in the context of supporting physical activity to control eating. For example, restructuring unproductive statements that could lead to missing a planned evening physical activity session would be adapted to address self-talk about circumventing dietary goals for the day. Along with self-regulation and maintaining regular physical activity, increasing FV consumption was a major emphasis of the 56-week treatment. Fidelity checks on approximately 15% of treatment sessions indicated few protocol deviations that were easily remedied.

Data Analyses

Because there was no systematic bias detected within the 8% of missing cases, the intention-to-treat approach incorporated the expectation-maximization algorithm[17] for imputation. For the primary analyses, a moderate effect of $f^2 = 0.15$ at the conservative statistical power level of 0.90 ($\alpha < 0.05$) necessitated a minimum sample size of 71.[18] SPSS Statistics version 22.0 (IBM, Armonk, NY) was used for the statistical analyses.

Linear bivariate relationships first were calculated across changes in daily consumption of food groups and weight, separately from baseline to months 6, 12, and 24, at which statistical significance was set at $\alpha < 0.05$ (2-tailed). Considering previous research and suggestions[19] and an absence of floor and ceiling effects, change (gain) scores were unadjusted for their baseline value. Mediation of the relationship of changes in FV intake and weight by change in self-regulation for eating over 6, 12, and 24 months was computed next using a bootstrapping method with 20,000 resamples.[20] Because directionality within the incorporated relationships was already established, 1-tailed analyses ($\alpha < 0.05$) were used to evaluate statistical significance. R^2 was calculated to determine significance of the overall models, and path *a* (predictor→mediator), path *b* (mediator→outcome), and path *c'* (predictor→outcome, controlling for the mediator) were also calculated as β values (Figure 1). Mediation significance was established when the bias-corrected and accelerated 95% confidence intervals did not include 0. Change in physical activity was tested for its significance as a covariate.

On the basis of previous suggestions,[21] the presence of a reciprocal (bidirectional) relationship between changes in FV intake and self-regulation also was tested by reversing the position of the predictor and mediator variables in paired equations. If significant mediation was found in both equations, then a reciprocal relationship had been detected.

RESULTS

Score Changes

Physical activity significantly increased (all p values < 0.001) from a baseline mean of 6.50 (SD = 7.89) to a mean of 35.16 (SD = 19.69) at month 6, a mean of 29.59 (SD = 16.63) at month 12, and a mean of 30.06 (SD = 17.41) at month 24. Self-regulation for eating at baseline (mean = 22.09, SD = 5.85) demonstrated a significant increase to month 6 ($mean_{change} = 9.79$, SD = 7.13, $p < 0.001$), month 12 ($mean_{change} = 6.25$, SD = 9.12, $p < 0.001$), and month 24 ($mean_{change} = 8.03$, SD = 8.49, $p < 0.001$). Table 1 details all other score changes.

Bivariate Relationships

FV intake changes from baseline to months 6, 12, and 24 served as significant predictors of changes in weight and bread and sweets consumption over 12 and 24 months and dairy consumption at 24 months (Table 1).

Mediation Analyses

When eating self-regulation was entered as a mediator of the relationships of change in FV intake and weight over 6, 12, and 24 months, change in physical activity did not demonstrate a significant effect on the prediction of weight change (β = -0.02, SE = 0.03; β = -0.04, SE = 0.04; and β = -0.07, SE = 0.04, respectively). As a result, this variable was removed from further analyses. The overall mediation models were each significant

Table 2. Mediation and reciprocal effects analyses (N = 74)[a]

			Path *a*		Path *b*		Path *c'*		Indirect effect through the mediator	
Predictor	Mediator	Outcome	β (SE)	p value	β (SE)	p value	β (SE)	p value	β (SE)	95% CI
Changes from baseline to month 6										
Fruit/vegetable intake	Self-regulation	Weight	1.26 (0.45)	0.003	-0.24 (0.08)	0.001	-0.45 (0.31)	0.073	-0.31 (0.20)	-0.695, -0.052
Self-regulation for eating	Fruit/vegetable intake	Weight	0.08 (0.03)	0.003	-0.45 (0.31)	0.073	-0.24 (0.08)	0.001	-0.04 (0.03)	-0.116, -0.002
Changes from baseline to month 12										
Fruit/vegetable intake	Self-regulation	Weight	1.57 (0.44)	< 0.001	-0.18 (0.09)	0.031	-0.67 (0.38)	0.042	-0.28 (0.21)	-0.753, -0.033
Self-regulation for eating	Fruit/vegetable intake	Weight	0.10 (0.03)	< 0.001	-0.67 (0.38)	0.042	-0.18 (0.09)	0.031	-0.07 (0.04)	-0.136, -0.015
Changes from baseline to month 24										
Fruit/vegetable intake	Self-regulation	Weight	1.75 (0.41)	< 0.001	-0.22 (0.09)	0.008	-1.19 (0.34)	< 0.001	-0.38 (0.18)	-0.792, -0.153
Self-regulation for eating	Fruit/vegetable intake	Weight	0.12 (0.03)	< 0.001	-1.19 (0.34)	< 0.001	-0.22 (0.09)	0.008	-0.14 (0.06)	-0.262, -0.055

[a] Analyses were based on a 1-tailed bootstrapping method to assess mediation that incorporated 20,000 resamples of the data (path *a* [predictor→mediator], path *b* [mediator→outcome], and path *c'* [predictor→outcome, controlling for the mediator]).[20]

CI = confidence interval; SE = standard error.

(R^2 = 0.19, p = 0.001; R^2 = 0.13, p = 0.006; and R^2 = 0.32, p < 0.001). Change in self-regulation demonstrated significant mediation in each of the 3 equations (Table 2).

Reciprocal Relationship Analyses

In models in which the predictor and mediator variables were reversed, there were significant mediations (Table 2). This indicated reciprocal, bidirectional relationships between changes in self-regulation and FV intake.

DISCUSSION

Findings supported relationships between both short- and long-term increases in FV intake and reduced weight loss and reductions in consumption of other food groups. This finding is consistent with previous suggestions that increased FV intake will reduce consumption of other food types and overall energy intake.[22] However, additional analyses within the present research suggest that the significant relationship between increased FV consumption and weight loss was achieved through (ie, significantly mediated by) increased self-regulation. Increasing positive (targeted) behaviors associated with eating more FV likely required participants to use more of their self-regulatory skills. As these skills were bolstered and used more effectively, improved eating behaviors emerged. Duplicating this scenario could advance the mutually reinforcing relationship that was documented through the reciprocal interaction between increases in FV intake and self-regulation. Both theory and systematic reviews strongly suggest the importance of self-regulation as a key mediator of weight-loss treatment effects.[6,23,24]

Although this study was limited by a single-group design with a volunteer sample that may have been especially motivated, it provides new analyses and a basis for further research into the dynamics of treatment-associated changes in diet, self-regulation, and weight loss. Extensions of this research should strengthen measurement instrumentation by incorporating validated food recall surveys that differentiate within food groups (eg, starchy vs nonstarchy vegetables) and accelerometers that can more objectively measure physical activity outputs. After implementing these measures and completing replications involving more ethnicities and sample types, a continued focus on FV intake and self-regulatory skills development can help increase the effectiveness of behavioral weight-loss programs that primarily are unreliable beyond the very short term.[25] Ultimately, medical professionals' support of patients' weight-management efforts will be enhanced. ❖

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

Acknowledgment

Kathleen Louden, ELS, of Louden Health Communications provided editorial assistance.

How to Cite this Article

Annesi JJ. Effects of treatment-associated increases in fruit and vegetable intake on the consumption of other food groups and weight through self-regulatory processes. Perm J 2018;22:17-143. DOI: https://doi.org/10.7812/TPP/17-143

References

1. Sacks FM, Bray GA, Carey VJ, et al. Comparison of weight-loss diets with different compositions of fat, protein, and carbohydrates. N Engl J Med 2009 Feb 26;360(9):859-73. DOI: https://doi.org/10.1056/NEJMoa0804748.
2. Rolls BJ, Ello-Martin JA, Tohill BC. What can intervention studies tell us about the relationship between fruit and vegetable consumption and weight management? Nutr Rev 2004 Jan;62(1):1-17. DOI: https://doi.org/10.1111/j.1753-4887.2004.tb00001.x.
3. Epstein LH, Gordy CC, Raynor HA, Beddome M, Kilanowski CK, Paluch R. Increasing fruit and vegetable intake and decreasing fat and sugar intake in families at risk for childhood obesity. Obes Res 2001 Mar;9(3):171-8. DOI: https://doi.org/10.1038/oby.2001.18.
4. Luyben PD. Applied behavior analysis: Understanding and changing behavior in the community—a representative review. J Prev Interv Community 2009;37(3):230-53. DOI: https://doi.org/10.1080/10852350902975884.
5. Bandura A. Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice Hall; 1986.
6. Bandura A. The primacy of self-regulation in health promotion. Appl Psychol 2005 Apr;54(2):245-54. DOI: https//doi.org/10.1111/j.1464-0597.2005.00208.x.
7. Annesi JJ. Exercise predicts long-term weight loss in women with class 1 and class 2 obesity through effects on emotional eating and its correlates. J Phys Act Health 2017 Nov 23:1-7. DOI: https://doi.org/10.1123/jpah.2017-0170.
8. Myplate and historical food pyramid resources [Internet]. Washington, DC: US Department of Agriculture; updated 2015 Oct 23 [cited 2017 Oct 25]. Available from: http://fnic.nal.usda.gov/dietary-guidance/myplate-and-historical-food-pyramid-resources.
9. Block G, Hartman AM, Dresser CM, Carroll MD, Gannon J, Gardner L. A data-based approach to diet questionnaire design and testing. Am J Epidemiol 1986 Sep;124(3):453-69. DOI: https://doi.org/10.1093/oxfordjournals.aje.a114416.
10. Mares-Perlman JA, Klein BE, Klein R, Ritter LL, Fisher MR, Freudenheim JL. A diet history questionnaire ranks nutrient intakes in middle-aged and older men and women similarly to multiple food records. J Nutr 1993 Mar;123(3):489-501.
11. Annesi JJ, Marti CN. Path analysis of cognitive-behavioral exercise treatment-induced changes in psychological factors leading to weight loss. Psychol Health 2011;26(8):1081-98. DOI: https://doi.org/10.1080/08870446.2010.534167.
12. Godin G. The Godin-Shephard Leisure-Time Physical Activity Questionnaire. Health & Fitness Journal of Canada 2011 Mar 1;4(1):18-22.
13. Jacobs DR Jr, Ainsworth BE, Hartman TJ, Leon AS. A simultaneous evaluation of 10 commonly used physical activity questionnaires. Med Sci Sports Exerc 1993 Jan;25(1):81-91.
14. Godin G, Shephard RJ. A simple method to assess exercise behavior in the community. Can J Appl Sport Sci 1985 Sep;10(3):141-6.
15. Annesi JJ, Unruh JL, Marti CN, Gorjala S, Tennant G. Effects of The Coach Approach intervention on adherence to exercise in obese women: Assessing mediation of social cognitive theory factors. Res Q Exerc Sport 2011 Mar;82(1):99-108. DOI: https://doi.org/10.1080/02701367.2011.10599726.
16. Research-tested intervention programs (RTIPs): Weight Loss For Life [Internet]. Bethesda, MD: National Cancer Institute; 2015 [cited 2017 Oct 25]. Available from: https://rtips.cancer.gov/rtips/programDetails.do?programId=24805736.
17. Schafer JL, Graham JW. Missing data: Our view of the state of the art. Psychol Methods 2002 Jun;7(2):147-77. DOI: https://doi.org/10.1037/1082-989X.7.2.147.
18. Cohen J, Cohen P, West SG, Aiken LS. Applied multiple regression/correlation analysis for the behavioral sciences. 3rd ed. Mahwah, NJ: Erlbaum; 2003.
19. Glymor MM, Weuve J, Berkman LF, Kawachi I, Robins JM. When is baseline adjustment useful in analyses of change? An example with education and cognitive change. Am J Epidemiol 2005 Aug 1;162(3):267-78. DOI: https://doi.org/10.1093/aje/kwi187.
20. Preacher KJ, Hayes AF. Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. Behav Res Methods 2008 Aug;40(3):879-91. DOI: https://doi.org/10.3758/BRM.40.3.879.
21. Palmeira AL, Markland DA, Silva MN, et al. Reciprocal effects among changes in weight, body image, and other psychological factors during behavioral obesity treatment: A mediation analysis. In J Behav Nutr Phys Act 2009 Feb 9;6:9. DOI: https://doi.org/10.1186/1479-5868-6-9.
22. Ledoux TA, Hingle MD, Baranowski T. Relationship of fruit and vegetable intake with adiposity: A systematic review. Obes Rev 2011 May;12(5):e143-50. DOI: https://doi.org/10.1111/j.1467-789X.2010.00786.x.
23. Teixeira PJ, Carraça EV, Marques MM, et al. Successful behavior change in obesity interventions in adults: A systematic review of self-regulation mediators. BMC Med 2015 A[r 16;13:84. DOI: https://doi.org/10.1186/s12916-015-0323-6.
24. Teixeira PJ, Silva MN, Coutinho SR, et al. Mediators of weight loss and weight loss maintenance in middle-aged women. Obesity (Silver Spring) 2010 Apr;18(4):725-35. DOI: https://doi.org/10.1038/oby.2009.281.
25. Mann T, Tomiyama AJ, Westling E, Lew AM, Samuels B, Chatman J. Medicare's search for effective obesity treatments: Diets are not the answer. Am Psychol 2007 Apr;62(3):220-33. DOI: https://doi.org/10.1037/0003-066X.62.3.220.