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Physical Activity and Dietary Behavior Change in Internet-Based Weight Loss Interventions: Comparing Two Multiple-Behavior Change Indices

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Abstract

Objective—To investigate the effects of two Internet-based weight loss interventions on physical activity (PA) and dietary behaviors using two approaches for computing combined behavior change.

Method—Participants were 352 overweight/obese women and men completing 12-month interventions in San Diego, California during 2002–2007. Moderate-to-vigorous PA (MVPA) and sedentary time were measured with accelerometers, and dietary fat and fruit and vegetable intake were assessed with food frequency questionnaires. Longitudinal analyses tested the effect of the intervention on combined health behavior change quantified using a standardized residualized change index (SRCI) and a risk factor change index (RFCI).

Results—At baseline, participants engaged in an average of 153 min/week of MVPA and 525 min/day of sedentary time, and consumed 37% of calories from fat and < 3 fruits and vegetables per day. The interventions had a significant effect on combined behavior change as measured with each approach ($p < 0.001$). The intervention effect was larger ($p < .001$) when evaluated using the SRCI (standardized regression coefficient [Beta] = 0.30) than the RFCI ($\beta = -0.18$).

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Conclusion—Interventions that target both PA and dietary behaviors appear effective. The SRCI was more sensitive for evaluating the intervention, but the RFCI may be easier to use for communicating public health significance.

Keywords

evaluation studies as topic; health behavior; risk factors; theoretical models

Interventions that target multiple health behaviors have the potential to improve outcomes such as heart disease, cancer and stroke (Orleans, 2004, Prochaska, et al, 2008a, Pronk et al, 2004). A recent review found that multiple health behavior interventions resulted in greater weight loss than single behavior interventions (Sweet and Fortier, 2010). Although weight loss is often a main outcome of interest in multiple health behavior interventions, behavior changes are often used to evaluate effectiveness of intervention studies because weight loss expected from behavior change may not be detected in the short term. With the increasing focus on multiple-behavior interventions, it is important to determine the overall impact of an intervention across the targeted health behaviors.

Usual practice when evaluating behavior change in multiple behavior interventions is to analyze each behavior as a separate outcome. The problems of this approach include the potential for inflating type I error rate due to multiple significance testing and difficulty interpreting overall impact of an intervention. Prochaska et al. (2008b) described two approaches that allow change across multiple behaviors to be described using a standard metric: (1) to create an index by summing standardized change scores, which quantifies each behavior on the same metric; or (2) to sum the number of behaviors for which a participant meets an established criterion (e.g., based on authoritative guidelines) that was not met at baseline. An index that can measure change over multiple behaviors has the potential to better reflect an intervention's effectiveness in decreasing a population's risk for negative health outcomes and facilitate comparisons between multiple and single behavior change interventions.

The aim of the present study was to investigate the two aforementioned approaches for computing combined behavior change by using each approach to evaluate the effects of two Internet-based weight loss interventions targeting PA and dietary behaviors. The indices were also used to investigate co-variation in PA and dietary behaviors over time (i.e., whether change in one behavior was related to change other behaviors).

Methods

Participants

Participants were overweight or obese women and men enrolled in Internet-based randomized controlled weight loss interventions targeting PA and dietary outcomes (Patrick, et al, in press, Calfas, et al, 2006). The men's and women's interventions were conducted separately but were very similar and the measures were identical. The samples were combined for the present analyses to increase statistical power. Eight-hundred forty-two participants were enrolled at baseline (401 in the women's study and 441 in the men's study) and 597 (70.9%) completed the 12-month follow up. Only those with complete accelerometer data at both time points were included in the present study ($n = 352$). Incomplete accelerometer data resulted from one of several factors: not enough monitors for all participants, monitor malfunctioned, monitor was not worn for the required number of days, or monitor was not returned. Women and older participants were more likely to have complete accelerometer data than their counterparts ($p < .05$). At 12-month follow up, 77%

of control group participants had complete accelerometer data compared to 68% of intervention group participants ($p = .02$).

Procedures

Men were recruited from the community through newspaper and radio advertisements and posted fliers and women were recruited through their primary care providers. Participants were required to have a BMI between 25 and 40, although 14 participants with a BMI out of this range were included because of a small discrepancy between their self-reported height and weight at screening and their measured height and weight at the baseline visit. Eligible participants had computer Internet access, were in good general health, not pregnant or planning to be pregnant, able to read and speak English, and able to engage in moderate intensity PA. Data collected at baseline and 12-month follow up were used in the present analyses. All study protocols were approved by the university institutional review board and all participants provided written informed consent. The authors have no known conflicts of interest.

Interventions

The interventions lasted 12 months and were based on Social Cognitive Theory (Bandura, 1989) and the Transtheoretical Model of Behavior Change (Prochaska, et al, 1997) Primary strategies of the interventions included skills teaching, goal setting, self-monitoring, and increasing social support and self-efficacy. An interactive web-based program was created to help participants set goals relative to their initial status (i.e., stage of change) on each of the behavioral targets. Goals were broken into proximal steps ultimately leading to the following long-term goals that were consistent with accepted guidelines (Centers for Disease Control and Prevention, 2005): increasing fruit and vegetable intake to 5–9+ servings/day; decreasing total fat to $< 30\%$ of total calorie consumption; increasing PA to 30–60 min/day 5–7 days/week; increasing steps per day measured by pedometer to $\geq 10,000$ (men only); and participating in strength training twice/week targeting at least two body areas (upper-body, lower-body and core; men only). Participants completed monthly web-based activities including learning about and applying a new behavioral skill and were encouraged to report progress on their goals and set new goals on a weekly basis. Tailored graphical feedback was provided that portrayed both improvements and instances when behaviors fell below previously attained levels. Women received monthly telephone calls from study counselors and men received calls approximately every three months. The control condition in the women's study was a wait-list. In the men's study, the control condition had access to a website that contained general health information topics (e.g., information on sun exposure protection and worksite injury prevention).

Measures

Dietary fat and fruits and vegetables—Participants completed the self-administered Fred Hutchinson Cancer Research Center Food Frequency Questionnaire (FFQ) which asked participants to report foods consumed over the last month and indicate portion size as small to large based on a stated medium portion size. (Patterson, et al, 1997, Patterson, et al, 1999). Variables for the present study were daily percent energy from total dietary fat and servings of fruit and vegetables/2000 kilocalorie.

Physical activity and sedentary time—Actigraph accelerometers (model 7164 with 1-minute epochs) worn on the right hip were used to assess PA across 3–7 days (Troost, et al, 2005). Thirty consecutive 0 counts indicated an invalid hour. Minutes of moderate-to-vigorous PA (MVPA) were calculated using a cut point of ≥ 1952 counts per minute

(Freedson, et al, 1998). Sedentary time was defined as < 100 counts (e.g., Healy, et al, 2008, Matthews, et al, 2008).

Combined health behavior change indices—Two of the indices described by Prochaska et al. (2008b) were used in the present study and results were compared between approaches. The standardized combined change index was calculated using residual change scores that were computed for each behavior by regressing the 12-month score on the baseline score and standardizing the values to have a mean of zero and standard deviation of 1 (Tucker, et al, 1966, Veldman and Brophy, 1974). A sum of the four standardized residualized change scores was taken to create the standardized residualized change index (SRCI; see Table 1 for details). Changes in dietary fat intake and sedentary time were reverse scored such that positive values indicated improved health behaviors.

The risk factor change index (RFCI) was calculated by taking the difference of the number of risk behaviors (i.e., not meeting guidelines) at 12-months from the number of risk behaviors at baseline. Participants could have a value ranging from -3 to 4 with negative numbers indicating a reduction in risk. Guidelines were engaging in ≥ 150 minutes of MVPA/week, and consuming ≥ 5 servings of fruit and vegetables/day and $\leq 35\%$ of calories from fat (USDHHS, 2005, USDHHS, 2008). A cutoff point of > 8 hours/day was chosen to define risk for sedentary time because it is just above the national average in adults (Matthews, et al, 2008).

Analysis

Multiple regression models tested the effect of the interventions on combined health behavior change quantified by each index. The initial models adjusted for gender and additional models adjusted for gender and baseline index score. Co-variation was investigated using multiple regression models that tested the effect of changing (for the SRCI) or decreasing risk (for the RFCI) for one behavior on each combined behavior change index score. For the co-variation models, a separate index was calculated that did not include the predictor behavior (e.g., the index used to examine the relationship between change in MVPA and combined behavior change did not include MVPA). Models were adjusted for gender and intervention group membership and additional models also adjusted for baseline index score (sum of z-scores for each behavior at baseline or number of risk behaviors at baseline), and baseline predictor behavior score (z-score or risk status). Z tests were used to determine whether regression coefficients differed between the SRCI models and RFCI models (Clogg, et al, 1995, Paternoster, et al, 1998).

Results

Descriptive characteristics of the study sample ($n = 352$) are presented in Table 1 and did not differ between study completers and non-completers. Mann Whitney (for continuous variables) and chi-square (for risk variables) identified no significant differences in PA and dietary behaviors between groups at baseline ($p < .05$). Baseline and 12-month data for each of the behavioral outcomes are presented in Table 2 separately for the intervention and control groups. Distributions of change scores are presented in Table 3 for each index for the intervention and control group. The adjusted correlation between the two indices was -0.72 ($p < 0.001$).

The interventions had a significant effect on combined behavior change as measured by both indices (see Table 4). Participants in the intervention group increased their positive health behavior z-score by an average of 1.34 ($p < 0.001$) standard deviation units and reduced their overall risk by an average of 0.41 (almost half) of a risk factor ($p < 0.001$). Models not adjusted for baseline index score produced only slightly different coefficients. The absolute

value of the standardized beta coefficient for the effect of the interventions was larger for the models using the SRCI than the models using the RFCI ($\beta = |0.28|$ vs. $|0.18|$; $z = 3.58$; $p < .001$).

The co-variation models using the SRCI indicated that changes in MVPA ($B = 0.42$; $p < 0.001$), sedentary time ($B = -0.34$; $p < 0.001$), and dietary fat intake ($B = -0.26$; $p < 0.05$) were related to combined behavior change in the expected direction (see Table 5). Fruit and vegetable intake was not associated with combined behavior change. The co-variation models using the RFCI revealed no statistically significant associations between reducing risk for one behavior and combined risk reduction for multiple behaviors (see Table 6). The absolute values of the standardized beta coefficients for the co-variation analyses were larger for models using the SRCI ($\beta_s = |0.10|$ to $|0.22|$) compared to those using the RFCI ($\beta_s = |0.00|$ to $|0.10|$); however, these differences in magnitude were not statistically significant ($z_s = 0.10$ to 1.05).

Discussion

The web-based weight loss interventions targeting dietary and PA change resulted in significant positive changes in indices of multiple health behaviors. Fifty-five percent of participants in the intervention group and 35% in the control group made an improvement in the positive direction based on the SRCI, while 52% of participants in the intervention group and 36% of the control group reduced their risk factor score by at least one risk factor. These results were similar to those of a multiple health behavior intervention that used telephone counseling and found that 53% and 33% of intervention and control group participants, respectively, reduced their risk factor score by at least one risk factor (Lawler, et al, 2010). Using the number needed to treat (NNT) measure of the effectiveness of the intervention, the multiple behavior change metrics suggest that the intervention delivered for 1-year provided benefit on at least one targeted behavior to one in every five individuals (SRCI) or one in every seven (NNT = 6.25 for RFCI). Thus, a low-cost easy to disseminate web-based program can potentially have a meaningful public health impact on health behaviors.

To our knowledge, this was the first multiple health behavior study to perform analyses using a continuous combined behavior change index. The SRCI was more sensitive to change in the present study. This is not surprising because it was expected that a continuous measure would have more power to detect relationships compared to an ordinal measure. For the SRCI, higher z-scores generally indicated more positive changes in health behaviors. The exceptions were when the participant had a very high or low baseline score and made a small behavior change. In these cases the index score was near zero but the sign may have been positive or negative (i.e., unrelated to the direction of behavior change). The patterns of findings suggest that the SRCI is accurate in quantifying behavior change compared to raw scores and accounts for baseline status. A disadvantage to using the SRCI is that the metric may be hard to interpret. However, the RFCI may be considered a more conservative approach than the SRCI because a threshold of behavior has to be reached to change the value of the index (i.e., a person could make significant a significant behavior change without crossing the criterion line for meeting the guideline). A limitation to both indices is that the behaviors are equally weighted in the index, though they may not be equally related to health outcomes.

Co-variation of behavior change over time was supported, indicating that changing one behavior may help in changing others. This is consistent with other multiple behavior interventions that found PA and dietary behaviors to co-vary over time (Johnson, et al, 2008, Lawler, et al, 2010, Sweet and Fortier, 2010). The exception was that change in fruit and vegetable consumption was not related to overall multiple behavior change. This unexpected

finding could have been because fruit and vegetable intake was the most readily changed behavior in this sample, suggesting that it was the easiest behavior for participants to change but was not necessarily related to changes in other behaviors. Fat intake co-varied with combined behavior change, suggesting that some aspect of diet and PA behaviors do change together. MVPA had the strongest correlation with the multiple behavior change indices. There was no evidence that any behavior in this study appeared to be a barrier to multiple-behavior changes.

Present findings may not generalize beyond overweight/obese adults. It is possible that the evaluation of the interventions was biased because participants in the control group were more likely to have complete accelerometer data than those in the intervention group. However, this difference is not likely to have biased the comparison between the two indices. Study strengths included the use of a prospective design and objective and validated measures.

Present findings support the effectiveness of multiple health behavior interventions and the validity of two multiple health behavior change indices. The SRCI was more sensitive for evaluating the intervention, but the RFCI may be easier to use for communicating public health significance of an intervention program to lay audiences. Future studies should explore methods of combined behavior change that take into account the relative influence of each behavior on health. Evidence is building to suggest that diet and PA behaviors co-vary in multiple health behavior interventions (Johnson, et al, 2008, Lawler, et al, 2010), thus providing further support for interventions that target both dietary and PA behaviors.

Highlights

We evaluate behavior change in a weight loss intervention using two approaches.

The intervention resulted in significant overall behavior change compared to control.

A continuous combined behavior score was more sensitive for evaluation purposes.

A combined risk factor score was more useful for interpretation.

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Table 1

Descriptive characteristics of study sample (n = 352)

	Intervention (n = 163)	Control (n = 189)
Age range	18–56	18–56
Mean age (SD)	44.3 (7.9)	42.2 (8.7)
BMI range	23.1–41.7	25.3–43.3
Mean BMI (SD)	32.2 (4.3)	33.3 (4.4)
% women	52.8	51.9
% with college degree	56.2	58.2
% White non-Hispanic	69.9	69.8
% Hispanic	6.7	7.9
% Asian	4.9	3.2
% Black	4.9	4.9

SD = standard deviation; This study included overweight and obese adults in San Diego, California during 2002–2007.

Table 2

Baseline and 12-month raw and risk scores for each health behavior (n = 352)

	Group	Raw score					At risk	
		Baseline		12-month		75 th %tile	Baseline	12-month
		25 th %tile	Median	75 th %tile	25 th %tile	Median	%	%
MVPA(min/week)	Intervention	92.0	151.7	247.3	95.2	162.0	274.4	48.5
	Control	93.9	165.7	303.9	106.0	165.0	291.3	47.1
Sedentary (min/day)	Intervention	469.7	539.4	606.3	454.3	532.9	582.9	71.8
	Control	453.2	511.7	582.7	458.5	520.7	579.5	66.7
Dietary fat (% calories from fat)	Intervention	32.4	37.5	41.2	26.7	32.6	38.5	62.0
	Control	31.1	35.5	40.2	29.5	34.7	39.7	52.9
Fruit and vegetable (servings/day)	Intervention	2.0	2.8	4.3	3.1	5.3	8.0	82.2
	Control	1.7	2.8	4.1	2.4	3.6	6.2	81.4
								67.6

MVPA = moderate to vigorous physical activity; Intervention group N = 163; Control group N = 189; This study included overweight and obese adults in San Diego, California during 2002–2007.

Table 3
Distribution of health behavior change scores for each index for intervention and control groups (n = 352)

Standardized residualized change index score ^a				
	Mean (SD)			
	1 st quartile	2 nd quartile	3 rd quartile	4 th quartile
Intervention group (N = 163)	-2.00 (0.800)	-0.36 (0.33)	1.24 (0.51)	4.01 (1.95)
Control group (N = 189)	-3.15 (1.02)	-1.40 (0.33)	-0.07 (0.41)	2.10 (1.22)

Change in number of health risk behaviors				
	% of participants ^b			
	1 or more	0	-1	-2 -3 or more
Intervention group (N = 163)	14.1	33.7	30.1	16.6 5.5
Control group (N = 189)	28.8	35.3	26.2	7.0 2.7

Note:

^a Higher scores indicate more positive changes in health behaviors;

^b Negative scores indicate reduced risk behaviors. This study included overweight and obese adults in San Diego, California during 2002–2007.

Table 4

Relationship of intervention vs. control for each combined health behavior change index (n = 352)

	Intercept	Unstandardized B	95% CI	Standardized β
Standardized residualized change index	Model 1 ^a	0.04	0.87, 1.82	0.28**
	Model 2 ^b	1.34**	0.86, 1.82	0.28**
Risk factor change index	Model 1 ^a	-0.39	-0.73, -0.26	-0.22**
	Model 2 ^b	-0.50**	-0.61, -0.20	-0.18**

Note:

^a Adjusted for gender;

^b Adjusted for gender and baseline index score;

CI = confidence interval; B = estimated unstandardized regression coefficient; β = estimated standardized regression coefficient;

** p < 0.001; This study included overweight and obese adults in San Diego, California during 2002–2007.

Table 5

Relationship between change in one health behavior and the standardized residualized change index^a (n = 352)

	Intercept	Unstandardized B	95% CI	Standardized β
MVPA change				
Model 1 ^b	0.02	0.42**	0.23, 0.61	0.22**
Model 2 ^c	0.02	0.42**	0.23, 0.61	0.22**
Sedentary change				
Model 1 ^b	0.04	-0.34**	-0.54, -0.14	-0.17**
Model 2 ^c	0.04	-0.34**	-0.53, -0.14	-0.17**
Dietary fat change				
Model 1 ^b	0.02	-0.26*	-0.47, -0.06	-0.13*
Model 2 ^c	0.02	-0.26*	-0.47, -0.06	-0.13*
Fruit and vegetable change				
Model 1 ^b	0.00	-0.18	-0.39, 0.03	-0.10
Model 2 ^c	0.00	-0.18	-0.40, 0.03	-0.10

Note: MVPA = moderate to vigorous physical activity;

^a A separate index excluding the predictor variable was created for each model;

^b Adjusted for gender and intervention group membership;

^c Adjusted for baseline predictor behavior z-score and baseline standardized index score; ;

CI = confidence interval; B = estimated unstandardized regression coefficient; β = estimated standardized regression coefficient;

* p < 0.05;

** p < 0.001;

This study included overweight and obese adults in San Diego, California during 2002–2007.

Table 6

Relationship between reduced risk in one health behavior and the risk factor change index^a (n = 352)

	Intercept	Unstandardized B	95% CI	Standardized β
Reduced MVPA risk				
Model 1 ^b	-0.28	0.25	-0.06, 0.56	0.08
Model 2 ^c	0.89	0.27	-0.02, 0.55	0.09
Reduced sedentary risk				
Model 1 ^b	-0.29	0.29	-0.01, 0.59	0.10
Model 2 ^c	0.60	0.28	-0.04, 0.60	0.10
Reduced dietary fat risk				
Model 1 ^b	-0.27	-0.04	-0.54, 0.45	-0.01
Model 2 ^c	0.79	0.00	-0.45, 0.45	0.00
Reduced fruit and vegetable risk				
Model 1 ^b	-0.04	0.22	-0.37, 0.82	0.04
Model 2 ^c	0.92	0.21	-0.32, 0.75	0.04

Note: MVPA = moderate to vigorous physical activity;

^a A separate index excluding the predictor variable was created for each model;

^b Adjusted for gender and intervention group membership;

^c Adjusted for baseline predictor behavior risk score and baseline risk index score; ;

CI = confidence interval; B = estimated unstandardized regression coefficient; β = estimated standardized regression coefficient;

* p < 0.05;

** p < 0.001;

This study included overweight and obese adults in San Diego, California during 2002–2007.