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Impact of a Weight Management Intervention on Eating Competence: Importance of Measurement Interval in Protocol Design

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Abstract

Purpose: To examine changes in eating competence (EC) in 12-month weight loss intervention.

Design: Randomized, parallel-arm with weight loss phase (baseline to month 4) and weight-maintenance phase (months 4-12).

Setting: Face-to-face in University classrooms, supervised and self-directed fitness sessions at University fitness center, and home.

Participants: Premenopausal, mostly college-educated Pennsylvania women, body mass index >25 (n = 101).

Intervention: Twenty-eight, 1-hour classes tailored for extremes of the Dietary Guidelines' fat recommendations, based on social cognitive theory, problem-based learning delivery over 12 months. Exercise component included supervised and self-directed stretching, aerobics, and strength training.

Measures: Anthropometrics, lipid profile, blood pressure, 24-hour dietary recalls, cognitive behavioral measures, Satter Eating Competence Inventory (ecSI).

Analysis: General linear model repeated measures analysis of variance for outcome variables.

Results: A total of 40% (n = 40) completed the ecSI. Overall, education and supervised exercise session attendance were 77% and 88%, respectively. Similar weight loss for lower and moderate fat groups (6.7 kg and 5.4 kg). The EC was unchanged baseline to month 4 but increased significantly from months 4 to 12, baseline to month 12 for both groups. The EC change baseline to month 12 was inversely associated with weight change from baseline to months 4 and 12.

Conclusion: Weight management interventions, likely to introduce concerns with eating attitudes, behaviors, and foods, can reduce EC. Short-term measurement of EC change captures these consequent adjustments without opportunity to regain self-efficacy. Extending the measurement interval better reflects intervention impact on EC.

Keywords
eating behavior, behavioral research, lifestyle, weight reduction programs, health impact assessment, lifestyle

Purpose

The Satter Eating Competence Model (ecSatter) has been described as "an intra-individual approach to eating and food-related attitudes and behaviors that entrains positive bio-psychosocial outcomes."[1(p 2)] ecSatter reflects a state of being that arches toward an end point of health and well-being but not with messages that include restriction, avoidance, and weight-centering commonly used in advice about health and nutrition. Rather than focus on specific foods or nutrients, diet plans or portion sizes, ecSatter addresses eating enjoyment, developing self-trust to select foods and amounts right for yourself, and letting genetics and lifestyle, rather than a planned dieting regimen, determine body weight. Thus, ecSatter suggests a stance that is counter to traditional nutritional advice.[2] According to Satter, the foundation of eating competence (EC) is giving permission to eat "adequate amounts of preferred food at predictable times"[(p S143)] but with the discipline to maintain meal and snack time structure and pay attention while eating.[2]

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ecSatter addresses 4 components of eating behavior: eating attitudes (EAs; eg, enjoying eating and feeling comfortable with eating), food acceptance (FA; eg, eating a variety of food and experimenting with food), internal regulation (IR; eg, eating to satisfaction and paying attention to eating), and contextual skills (CS; eg, planning and making time for eating and considering what is good for me).[3] Thus, it is of keen interest that EC is associated with higher dietary quality,[4-6] reduced cardiovascular risk factors,[7] less disordered eating,[3,8-10] normal body mass index (BMI),[3,8,11,12] better food resource management skills,[3,8] being physically active,[1] better sleep quality,[13] and positive parent feeding practices for school-age[5,14] and preschool children.[15] These are the behaviors and outcomes that medical and public health professionals strive to promote and attain. Therefore, evaluating interventions for their impact on EC and ultimately developing programs aligned with EC are not only prudent but also imperative.

Satter has identified key elements of an EC approach for nutrition education.[16] These elements include building relationships and acceptance of learners' foodways, emphasis on structured, and attentive eating coupled with sensitivity to body rhythms; food selection being guided by pleasure coupled with consideration of "what is good for me"; avoiding prescriptive regimens, encouraging sensitivity to hunger and appetite, and neutralizing disinhibition by avoiding food restriction; and finally joining learners where they are in their approach to eating and working with them from that point not from the point of the educator. To gauge adherence to ecSatter and ultimately program impact on EC, a 16-item inventory (Satter Eating Competence Inventory [ecSI]) has been developed, confirmed reliable,[17] validated with a general audience,[3] and subsequently revised, then revalidated with a low-income sample (ecSI/LI)[8] and tested suitable for general audiences (ecSI version 2.0).[18] Nutrition and public health educators have shown interest in using this inventory as well as revising or designing programs and courses to include ecSatter tenets.[9-12]

A United States Department of Agriculture (USDA)-funded study of nutrition education and physical activity for overweight and obese, but healthy, premenopausal women, offered an opportunity to examine changes in EC over a 12-month period with hypocaloric (ie, for weight loss; baseline through month 4) and eucaloric (ie, in calorie balance for weight maintenance; month 5 through month 12) phases. The Weight Optimization: Revamping Lifestyles using the *Dietary Guidelines* (WORLD) study examined the effects of a year-long, theory-based, free-living intervention emphasizing diets consistent with the *Dietary Guidelines* and at the extremes of the dietary fat recommendations (ie, 20% and 35% of energy from fat) during weight loss and maintenance of a healthy body weight. A premise of the WORLD study was that weight-management interventions based on the *Dietary Guidelines* that offer relatively flexible dietary prescriptions may promote long-term adherence and desired health outcomes, including cognitions and behaviors relative to eating. Therefore, the purpose of this investigation was to examine one of these behaviors—EC—and how it changed over the phases of the WORLD study.

Methods

Sample

Premenopausal women residing in central Pennsylvania were recruited through advertisements in the local paper and e-mails sent to the Pennsylvania State University's faculty and staff listserv. Following an initial telephone screening interview to assess medical history, interested and eligible women completed medical, clinical, and psychosocial screening at the General Clinical Research Center at the Pennsylvania State University. Inclusion criteria were being female between the ages of 21 and 50, a BMI classification of overweight or obese (25-39.9 kg/m^2), as well as ability to comply with the study protocol (eg, able to read English, attend sessions, and provide requisite end point samples). Screening low-density lipoprotein (LDL)-cholesterol was required to be between the 25th and 90th percentile of the National Health and Nutrition Examination Survey (ie, 2.60-4.93 mmol/L or 97-190 mg/dL). Levels >130 mg/dL are considered elevated[19]; therefore, the sample included women with normal and elevated LDL-cholesterol levels. The upper limit for BMI was set to minimize the possibility of serious comorbidities associated with morbid obesity and because morbidly obese individuals may have special exercise needs.[20] Exclusion criteria included (1) triglycerides >3.94 mmol/L; (2) use of lipid-lowering agents (ie, medications, psyllium, fish oil, soy lecithin, and phytoestrogens); (3) lactating, being pregnant, or wishing to become pregnant during the study period; (4) having a weight loss ≥10% body weight within the 6 months prior to the study; (5) following vegetarian or weight loss diets at screening; (6) having any of the following conditions: stroke, diabetes, liver disease, kidney disease, or autoimmune diseases; and (7) not meeting scoring cutoffs of the screening instruments.

Design

Of the 616 women recruited to the study, 101 participants met the inclusion criteria and were randomized, using a pseudorandom number generator, to 1 of 2 weight management groups[1] that differed in educational focus (20% or 35% kcal from fat). As shown in Figure 1, the parallel-arm study consisted of a weight loss phase (months 1 through 4) and a weight-maintenance phase (months 5 through 12). During the weight loss phase, participants were instructed to consume a hypocaloric diet consistent with the *Dietary Guidelines* recommendations that were current at the time this study was conducted.[21] An individualized calorie range was calculated by the Harris-Benedict equation[22] for each participant to induce weight loss of 0.45 to 0.91 kg/wk through a caloric deficit of 500 to 1000 calories per day, with a weight loss goal of 10% of initial body weight. Participants then transitioned to weight maintenance with instruction to consume a eucaloric diet consistent with the *Dietary Guidelines*.

The institutional review board at the Pennsylvania State University approved the experimental protocol and all

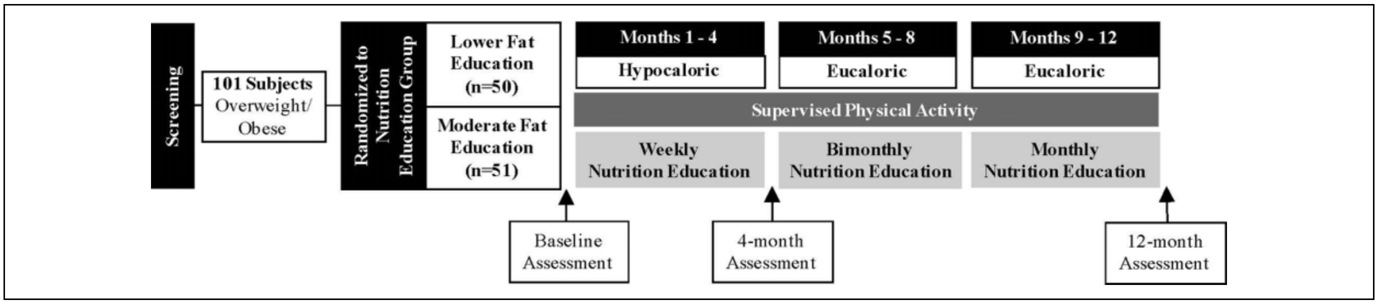

Figure 1. Study design.

participants provided written informed consent. This study was registered at www.clinicaltrials.gov #NCT00847574.

Intervention

The intervention consisted of pilot-tested group nutrition education sessions, held separately for each treatment group, and supervised exercise. The educational program was based on the social cognitive theory (SCT)[23] and delivered with a problem-based learning approach,[24,25] such that specific SCT constructs that target behaviors important for health were emphasized (Table 1) and participants actively participated in the learning process. The educational materials were based on the *Dietary Guidelines* and tailored for the 2 extremes of the dietary fat recommendations (20% and 35% of kcals). The intervention was delivered in 28 one-hour education sessions led by nutritionists throughout the 12-month intervention. Sessions were held weekly for the first 4 months, bimonthly for the next 4 months, and monthly for the last 4 months of the study (Figure 1). Some sessions were information-based and addressed topics such as the food groups (ie, fruits and vegetables, lean meats and beans, and grains) and certain nutrients (ie, fat, fiber, sodium, potassium, and calcium) emphasized in the *Dietary Guidelines*. Other lessons were behavior-based and presented information about behaviors that influence one's lifestyle and health, such as goal setting, self-monitoring, portion estimation, and snacking management. The exercise component, presented as part of the educational component, consisted of daily stretching and 5 aerobic sessions, 2 supervised and 3 self-directed, and 2 unsupervised strength-training sessions per week (Figure 1). The unsupervised strength-training routine consisted of 2 sets of each basic strength-training exercise at home or in the training room. Weekly logs specifying unsupervised exercise were shared in the supervised sessions.

Measures

Screening was completed with self-reported, validated instruments that included the Beck Depression Inventory-II,[26] Eating Attitudes Test-26 (EAT-26),[27] Gormally Cognitive Factors Related to Binge Eating Scale (COGEAT),[28] and Physical Activity Readiness Questionnaire (PAR-Q).[29] The Beck Depression Inventory-II identifies level of depression; EAT-26 measures concern regarding body weight, body shape, and eating; COGEAT measures levels of binge eating behavior; and the PAR-Q identifies presence of health problems that could prevent physical activity participation. Persons were excluded if Beck Depression Inventory-II score was $\geq$29 (severe depression), EAT-26 scores were >20, COGEAT scores were >30 (severe bingeing behavior), or PAR-Q was >2 (presence of multiple health problems that prevent physical activity participation). Demographics collected in addition to screening information included race/ethnicity and education level. Anthropometric, clinical, biochemical, dietary, physical fitness, cognitive-behavioral, and perceived quality of life (PQoL) data were collected at baseline and months 4 and 12 (Figure 1) using validated or tested instruments and procedures. In addition, weight satisfaction was reported at baseline.

Anthropometric. Weight was measured with a calibrated digital scale with the participant dressed in light indoor clothing without shoes. Height was obtained at screening with a calibrated wall-mounted stadiometer. Waist circumference was measured using an anthropometric measuring tape at the uppermost lateral border of the right iliac crest, according to the National Health and Nutrition Examination Survey (NHANES) III protocol.[30]

Clinical. Blood pressure was measured according to the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure 7 Guidelines.[31] Three blood pressure measurements were taken at 1-minute intervals and averaged.

Biochemical. Following an overnight fast, blood samples were collected and plasma was assayed for total cholesterol and triglycerides measured by enzymatic assay at Quest Diagnostics Incorporated (Baltimore, Maryland). High-density lipoprotein (HDL)-cholesterol was estimated according to the modified heparin–manganese precipitation procedure.[32] The LDL-cholesterol was calculated by the Friedewald equation.[33]

Dietary intake. Trained interviewers at Pennsylvania State University's Diet Assessment Center collected 24-hour dietary recalls by telephone from each participant on unannounced, random, nonconsecutive days (2 weekdays and 1 weekend day) using a multiple pass technique.[34] Food portion posters (2D Food Portion Visual; Nutrition Consulting Enterprises,

Table 1. Application of the Social Cognitive Theory (SCT) Constructs to Nutrition Education Lesson #11—"Fruits and Vegetables: It's Easy to Eat What You Need."

SCT Construct	Definition	Application
Situation	Person's perception of the environment	• Addressed misconceptions about canned and frozen fruits and vegetables
Behavioral capability	Knowledge and skill to perform a given behavior	• Discussed nutrients provided by fruits and vegetables • Included tips for increasing fruits and vegetables intakes
Expectations	Anticipatory outcomes of behavior	• Listed health conditions for which daily consumption of 5 servings of fruits and vegetables lowers risk
Self-efficacy	Person's confidence in performing a behavior and in overcoming barriers to that behavior	• Phrased title and text to increase confidence in ability to consume more fruits and vegetables (ie, "Fruits and vegetables can easily be added to your diet to improve your health.")
Self-control	Personal regulation of goal-directed behavior or performance	• Included checklist to enable self-reflection related to current fruits and vegetables consumption • Fostered self-reflection through questions related to fruits and vegetables intake and knowledge

Framingham, Massachusetts) were used to estimate portion sizes. Dietary recalls were collected and analyzed using the Nutrition Data System for Research software version 5.0 (Nutrition Coordinating Center, University of Minnesota, Minneapolis, Minnesota). Three-day average intakes were calculated to estimate intake at each time point.[35,36] Macronutrient and micronutrient intakes were determined, in addition to energy density of participant diets and Healthy Eating Index (HEI)-2005 scores.[37]

Cognitive behavioral

Satter Eating Competence Inventory. EC was measured with the self-report ecSI, which consists of 16 Likert-scaled items that are summed to yield a total score (possible score range: 0-48) and 4 subscale scores—EAs: 0-15; FA: 0-9; IR: 0-9; and CS: 0-15. ecSI total scores of 32 or higher indicate EC.[3] Validity, internal consistency, and test–retest reliability of the ecSI have been demonstrated.[3,17] Cronbach alphas for the ecSI scores were 0.79, 0.91, and 0.83 at baseline, month 4, and month 12, respectively.

Three-Factor Eating Questionnaire-R18. The self-reported Three-Factor Eating Questionnaire-R18 (TFEQ-R18), validated with obese adults,[38] includes 18 items to measure cognitive restraint (conscious restriction of food intake to control body weight or to promote weight loss), uncontrolled eating (tendency to eat more than usual due to loss of control over intake accompanied by subjective feelings of hunger), and emotional eating (inability to resist emotional cues). Items are scored 1 to 4 and summed; scale scores have the following ranges—cognitive restraint: 6 to 24; uncontrolled eating: 9 to 36; and emotional eating: 3 to 12. Higher scale scores indicate more of each behavior.

Perceived Quality of Life. The validated self-report PQoL includes 19, 11-point Likert-type scaled items (0-extremely dissatisfied and 10-extremely satisfied) summated to provide an overall score of general health satisfaction; higher score equals better quality of life.[39-41]

Analysis

All statistical analyses were performed with SPSS version 23 (Armonk, New York). Data normality was assured requiring a log transformation for HDL-cholesterol. Change scores and percentage change were calculated from baseline for each outcome variable. Pearson correlation coefficients were used to estimate interrelationships between variables. Predictive ability of baseline EC was tested with linear regression, reporting standardized β coefficients. Differences in dietary data between EC and non-EC at baseline were analyzed using a general linear model (GLM) controlling for energy. Comparisons strictly between 2 groups (eg, EC vs non-EC and study completers vs attriters) were completed with *t* tests. The EC tertile comparisons at month 12 were analyzed with 1-way analysis of variance (ANOVA); all tests were 2-tailed.

Participant change in EC including subscales was analyzed in a 3 × 2 repeated measures ANOVA with time (baseline, month 4, and month 12) as a within-participant factor and intervention group as a between-participant factor. For all analyses, Mauchly test revealed the assumption of sphericity was violated; this was addressed using the conservative lower bound correction. Subscales and survey items were compared over time with a repeated measures ANOVA using pairwise comparisons to test for interval specific differences. Significance was set at $P < .05$.

Results

Participant Characteristics

Participant characteristics are shown in Table 2. Of the 101 women randomly assigned to a study group, 59% (n = 60) completed the study (ie, provided anthropometric, biochemical, and dietary data at month 12 assessment; low-fat study group, n = 32; moderate-fat study group, n = 28) and 40 completed the ecSI at all assessment time points (baseline, month 4, and month 12). The ecSI completers did not differ in any baseline characteristics from those who attrited at baseline.

Table 2. Baseline Characteristics of Subjects.[a]

	Total Sample									
	All Participants (n = 101)		Low-Fat Study Group[b] (n = 50)		Moderate-Fat Study Group[b] (n = 51)		Study Completers[c] (n = 60)		ecSI Completers[d] (n = 40)	
Characteristic	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age (yr)	38.9	6.3	38.8	6.4	39	6.3	39.9	6.2	39.7	6.2
ecSI total score[b]	26.4	6.2	28.6	6.4	24.3	5.4	26.2	6.3	26.2	6.2
Eating attitudes[b]	9.2	3	9.9	2.9	8.6	3	9.3	2.9		2.9
Food acceptance	3.9	1.9	4.6	1.9	3.2	1.7	3.9	2	9	1.8
Internal regulation[b]	6.2	1.6	6.5	1.6	5.9	1.6	6.1	1.5	3.8	1.4
Contextual skills	7.1	2.6	7.7	2.6	6.6	2.4	7.0	2.5	6.2	2.4
Three factor eating questionnaire										
Uncontrolled eating	21.3	4.6	20.7	4.7	21.9	4.4	21	4.3	20.9	4.1
Cognitive restraint	14.2	2.8	14.3	2.6	14.1	2.9	14.3	2.7	14.2	2.6
Emotional eating	15.8	3.7	15.7	4.2	16	3.2	15.6	3.5	15.7	3.5
Gormally binge eating[b]	12	6.3	10.4	5.8	13.6	6.5	11.7	6.3	11.7	6.2
Beck depression inventory	5.4	4.4	4.8	4.4	5.9	4.3	5.3	4.3	4.9	4.7
Quality of life	6.7	1.1	6.8	1.1	6.6	1.1	6.8	1	6.9	1
Weight (kg)	83.1	13.2	84.5	13.5	81.7	13	83.1	12.8	83.3	12.7
BMI (kg/m^2)	30.8	4.3	31	4.4	30.6	4.1	30.8	4.2	30.7	4.2
Waist circumference (cm)	99.7	10.5	99.7	10.1	99.8	10.8	99.7	9.7	99.3	8.6
Blood pressure (mm Hg)										
Systolic	114.8	9.9	114.4	9.6	115.2	10.2	114.4	9.3	115	9.4
Diastolic	77.5	7.8	76.9	7.8	78	7.7	76.7	7.6	77.7	7.4
Cholesterol (mmol/L)										
Total	4.7	0.7	4.6	0.6	4.8	0.7	4.7	0.6	4.8	0.6
HDL	1.2	0.3	1.2	0.2	1.3	0.3	1.2	0.2	1.2	0.2
LDL	2.9	0.6	2.8	0.6	3	0.6	2.9	0.5	3	0.5
	No.	%	No.	%	No.	%	No.	%	No.	%
Race[e]										
White	94	94.9	46	95.8	48	94.1	59	98.3	40	100
Black	2	2	0	0	2	3.9	1	1.7	0	0
Other	3	3	2	4.2	1	2	0	0	0	0
Education[e]										
High school	10	10.1	4	8.3	6	11.8	8	13.3	4	10
Some college	13	13.1	5	10.4	8	15.7	4	6.7	3	7.5
Business/tech degree	10	10.1	1	2.1	9	17.6	6	10	4	10
College graduate	42	42.4	26	54.2	16	31.4	25	41.7	16	40
Graduate degree	24	24.2	12	25	12	23.5	17	28.3	13	32.5
Weight satisfaction[b]										
Satisfied	2	2	2	4.2	0	0	2	3.3	1	2.5
Neutral	2	2	1	2.1	1	2	1	1.7	1	2.5
Unsatisfied	56	56.6	26	54.2	30	58.8	36	60	24	60
Very unsatisfied	39	39.4	19	39.6	20	39.2	21	35	14	35
BMI category										
Overweight (25.0-29.9 kg/m^2)	52	51.5	25	50	27	52.9	31	51.7	20	50
Obese ($\geq$30.0 kg/m^2)	49	48.5	25	50	24	47.1	29	48.3	20	50

Notes: BMI = Body Mass Index; ecSI = ecSatter Inventory; HDL = High Density Lipoprotein—Cholesterol; LDL = Low Density Lipoprotein—Cholesterol; TFEQ = Three Factor Eating Questionnaire—R18; Gormally Binge Eating = Gormally Cognitive Factors Related to Binge Eating Scale.

[a]Values are expressed as mean (standard deviation) or frequencies (percentage of sample).

[b]Low- and moderate-fat study groups differed at baseline for total ecSI scores (p = .001), eating attitudes (p = .027), food acceptance (p < .001), and COGEAT (p = .012).

[c]Study completers provided anthropometric, biochemical, and dietary data at month 12 assessment.

[d]ecSI completers completed the ecSI at all assessment time points (baseline, 4 months and 12 months).

[e]Two participants who did not complete the study did not report race, education level, or weight satisfaction level at baseline.

Table 3. Comparison of Eating Competence Tertiles at Month 12.[a]

Variable	Eating Competence Tertiles			*P* Value
	Low (n = 14)	Medium (n = 11)	High (n = 15)	
Baseline Beck Depression Inventory	7.8 (5.3)[b]	4.2 (3.7)[b,c]	2.6 (3.6)[d]	0.008
Baseline TFEQ Cognitive Restraint	13.3 (2.9)	15.5 (2.5)	14.1 (2.1)	0.099
4-month TFEQ Uncontrolled Eating	20.2 (4.0)	16.4 (3.6)	17 (3.0)	0.025
4-month TFEQ Emotional Eating	15.3 (3.6)[b]	12 (2.8)[c]	11.9 (2.2)[c]	0.007
4-month Quality of Life	7.1 (1.2)[b]	7.8 (0.6)[b,c]	8.1 (1.0)[c,d]	0.036
12-month TFEQ Emotional Eating	14.5 (4.1)	12.4 (1.3)	12.1 (2.6)	0.077
12-month Quality of Life	7.1 (1.0)[b]	7.9 (0.8)[b,c]	8.1 (0.9)[c,d]	0.021
12-month HEI Score	73.3 (9.2)[b]	81.4 (5.6)[c]	77.2 (7.5)[b,c]	0.047
12-month Weight (kg)	84.8 (14.1)[b]	70.4 (7.5)[c]	75.3 (13.1)[b,c]	0.017
12-month BMI (kg/m^2)	30.9 (4.8)[b]	26.6 (2.9)[c]	27.4 (4.2)[b,c]	0.024
12-month Waist Circumference (cm)	100.9 (13.5)	91.4 (7.7)	93.4 (7.8)	0.051
12-month SBP (mm Hg)	115.2 (10.0)	106.3 (8.9)	109.9 (7.9)	0.052
12-month DBP (mm Hg)	79.9 (5.6)[b]	69.6 (9.1)[c]	74.1 (8.2)[b,c]	0.007

Abbreviations: BMI,body mass index; DBP,diastolic blood pressure; HEI,healthy eating index; SBP,systolic blood pressure; TFEQ,Three Factor Eating Questionnaire-R18.
[a]Values reported as means (standard deviation).
[b,c,d] Statistically significant post hoc differences.

Intervention and Weight Change

Nutrition education session attendance and exercise attendance (defined as coming into the training room for supervised exercise sessions) did not differ between study groups. Study completers attended an average of 20 (out of a possible 26) nutrition education sessions. In 4 weeks leading up to the 4-month assessment, study completers attended an average of 7 (out of a possible 8) supervised exercise sessions. In 4 weeks prior to the 12-month assessment, participants attended an average of 4 (out of a possible 8) supervised exercise sessions.

Weight loss after 1 year was similar for participants assigned to the lower-fat and moderate-fat study groups (−6.7 and −5.4 kg, respectively; $P < .001$ compared to baseline). The majority of weight loss occurred during the first 4 months (−5.0 and −5.1kg, respectively; $P < .001$) with a nonsignificant loss from month 4 to month 12 (−1.7 and −0.3 kg, respectively). Accordingly, a significant decrease in BMI was attained by month 4 in both study groups and maintained through month 12 (−2.5 and −2.0 units, respectively; time effect, $P < .001$). The amount of weight loss and change in BMI did not differ between study groups. Study completers did not differ from ecSI completers in weight loss pattern or study adherence.

Eating Competence at Baseline

Tenets associated with EC were affirmed. At baseline, participants who were eating competent (ecSI ≥32; n = 17, 18%) reported significantly lower scores for cognitive factors related to binge eating (8.3 vs 13.1; $P = .005$), depression (3.4 vs 5.8; $P = .01$), uncontrolled eating (18.9 vs 21.9; $P = .014$), and emotional eating (13.5 vs 16.4; $P = .003$) as well as had lower total cholesterol values (4.4 vs 4.8 mg/dL; $P = .034$) compared to those who were not eating competent (n = 76, 82%). In addition, compared to non-EC participants, those who were EC had significantly higher dietary intakes of protein (73.9 ± 2.6 g vs 67.2 ± 1.2 g; $P = .021$), animal protein (48.7 ± 2.8 g vs 42.0 ± 1.3; $P = .033$), vitamin D (4.8 ± 0.5 µg vs 3.4 ± 0.2; $P = .016$), and zinc (15.9 ± 2.2 mg vs 9.2 ± 1.0 mg; $P = .007$) when controlling for energy. Competent eaters had higher, but nonsignificant differences in intakes of iron, copper, calcium, folate, fiber, vitamin A, vitamin E, niacin, thiamin and riboflavin, and nonsignificantly lower intakes of fat, saturated fat, and sodium. Baseline EC predicted the Beck Depression Inventory score ($\beta = -.36$, $P < .001$), Gormally Cognitive Factors related to Binge Eating score ($\beta = -.38$, $P < .001$), TFEQ uncontrolled eating scale ($\beta = -.36$, $P < .001$), and TFEQ emotional eating scale ($\beta = -.39$, $P < .001$).

Eating Competence at Month 12

At the end of the intervention (month 12), participants who were eating competent were more likely than noneating competent participants to report lower baseline Beck Depression Inventory scores (2.95 vs 6.95; $P = .006$), higher quality of life at 4 months (7.95 vs 7.14; $P = .017$) and 12 months (8.07 vs 7.3; $P = .015$), and greater reductions in TFEQ emotional eating from baseline to 4 months (−3.9 vs −1.6; $P = .028$) and TFEQ uncontrolled eating from baseline to 4 months (−4.1 vs −0.8; $P = .015$) and baseline to 12 months (−3.8 vs −1.1; $P = 0.87$). In addition, at the end of the intervention, there was a trend for lower BMI in eating competent versus noneating competent participants (27.3 vs 29.6 kg/m^2; $P = .099$). Differences among EC tertiles at 12 months are presented in Table 3. Those in the lowest tertile had the highest weight, BMI, waist circumference, diastolic blood pressure, and systolic blood pressure at month 12, as well as the highest levels of depression at baseline, uncontrolled eating at month 4, and emotional

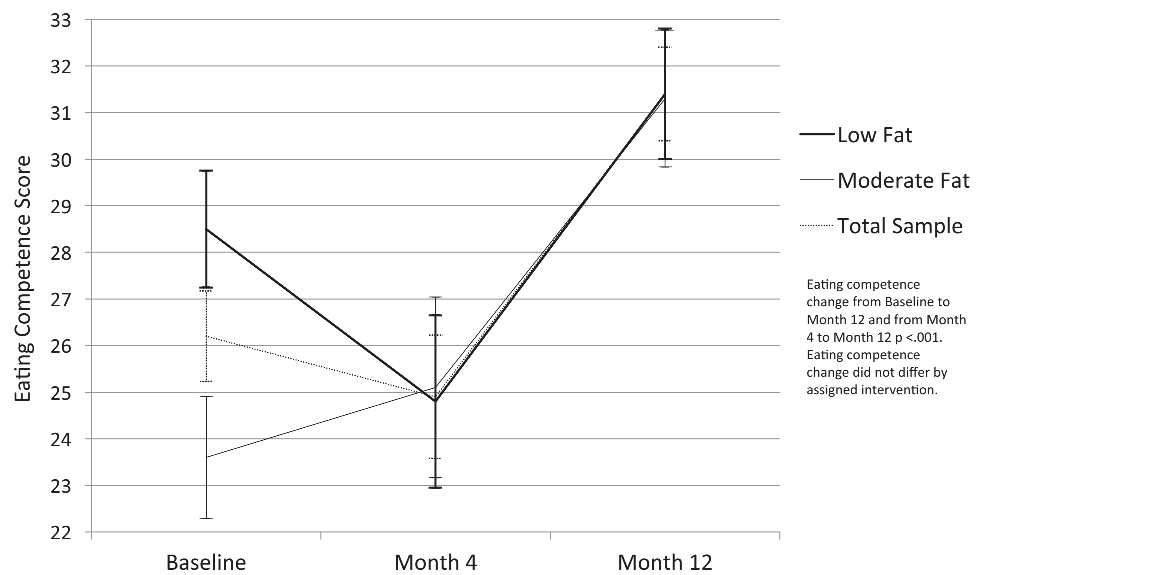

Figure 2. Change in eating competence for total sample (n = 40) and assigned intervention groups (low fat n = 21 and moderate fat n = 19).

Table 4. Change in Eating Competence Across Time (n = 40).[a]

ecSI Scales	Baseline Begin Hypocaloric Phase	Month 4 Begin Eucaloric Phase	Month 12
Total ecSI score[b,c]	26.2 (1.0)	24.9 (1.3)	31.4 (1.0)
Low fat	28.5 (1.2)	24.8 (1.8)	31.4 (1.4)
Moderate fat	23.6 (1.3)	25.1 (1.9)	31.3 (1.5)
Eating attitudes[d,e,c]	9.0 (0.4)	7.5 (0.6)	10.5 (0.4)
Low fat	9.8 (0.6)	7.3 (0.8)	10.6 (0.6)
Moderate fat	8.2 (0.6)	7.6 (0.9)	10.4 (0.6)
Food acceptance[b,f,g]	3.8 (0.3)	4.7 (0.3)	5.2 (0.3)
Low fat	4.7 (0.3)	4.8 (0.4)	5.6 (0.4)
Moderate fat	2.9 (0.4)	4.7 (0.4)	4.8 (0.5)
Internal regulation[h,i]	6.2 (0.2)	4.9 (0.3)	6.1 (0.2)
Low fat	6.2 (0.3)	4.8 (0.4)	6.0 (0.3)
Moderate fat	6.2 (0.3)	4.9 (0.4)	6.1 (0.3)
Contextual skills[b,i]	7.1 (0.4)	7.8 (0.5)	9.6 (0.4)
Low fat	7.9 (0.5)	7.9 (0.6)	9.2 (0.5)
Moderate fat	6.4 (0.5)	7.8 (0.7)	10.1 (0.5)

[a]Values reported as means (standard error). Low Fat [20% Kcals from fat (n = 21)] Moderate Fat [35% Kcals from fat (n = 19)]
[b]Baseline to Month 12, $p < 0.001$.
[c]Month 4 to Month 12, $p < 0.001$.
[d]Baseline to Month 12, $p < 0.01$.
[e]Baseline to Month 4, $p < 0.1$.
[f]Baseline to Month 4, $p < 0.05$.
[g]Pattern of change in food acceptance differed between assigned groups ($p = .032$).
[h]Baseline to Month 4, $p < 0.001$.
[i]Month 4 to Month 12, $p < 0.01$.

eating at months 4 and 12. In addition, the lowest tertile had the lowest cognitive restraint at baseline, quality of life at months 4 and 12, and HEI scores at month 12.

Change in Eating Competence Across Time

The proportion of participants who were EC increased from 15% at baseline to 20% at month 4 and 53% at month 12. A greater proportion of participants randomized to the lower fat intervention were EC compared to the moderate-fat group at baseline (29% vs 0%; $P < .05$), but differences were not significant at 4 or 12 months. EC significantly changed from month 4 to month 12 and baseline to month 12 ($P < .001$); change from baseline to month 4 was not significant. This pattern did not significantly differ between assigned interventions (Figure 2).

Table 5. Individual Eating Competence Survey Item Performance Over Time.[a]

ecSI Subscale	Item	Baseline to Month 12	Baseline to Month 4	Month 4 to Month 12
Eating attitudes and behavior	I am relaxed about eating	↔	↔	↔
	I am comfortable about eating enough	↑[b]	↓[c]	↑[d]
	I enjoy food and eating	↑[d]	↓[d]	↑[d]
	I am comfortable with my enjoyment of food and eating	↑[d]	↔	↑[d]
	I feel it is okay to eat food that I like	↑[b]	↔	↑[b]
Food acceptance	I experiment with new food and learn to like it	↑[d]	↑[b]	↔
	If the situation demands, I can "make do" by eating food I don't much care for	↑[d]	↑[c]	↔
	I eat a wide variety of foods	↑[b]	↔	↔
Internal regulation	I assume I will get enough to eat	↔	↓[d]	↑[d]
	I eat as much as I am hungry for	↔	↔	↔
	I eat until I feel satisfied	↔	↔	↔
Contextual skills	I tune in to food and pay attention to myself when I eat	↑[d]	↑[d]	↔
	I make time to eat	↔	↔	↑[b]
	I have regular meals	↔	↔	↑[b]
	I think about nutrition when choose what I eat	↑[d]	↔	↑[c]
	I generally plan for feeding myself. I don't just grab food when I get hungry	↑[d]	↑[b]	↑[b]

Abbreviation: ecSI, Satter Eating Competence Inventory.
[a]↑ represents score increase, ↓ represents score decrease, ↔ represents no score change.
[b]$P < .05$.
[c]$P < .01$.
[d]$P < .001$.

Participants who completed the ecSI at all 3 time points (n = 40) increased in EA, FA, and CS, but not IR, between baseline and month 12 ($P < .01$; Table 4). Pattern of change in EC subscale scores was not uniform. The EA tended to decrease from baseline to month 4 then increased beyond baseline between months 4 and 12. The IR also decreased from baseline to month 4 but rebounded to baseline levels between months 4 and 12. The FA increased from baseline to month 4 and was maintained thereafter. The CS did not change between baseline and month 4 but significantly increased between months 4 and 12.

The EC change from baseline to month 12 tended to be associated with decreased weight from baseline to month 4 ($r = -0.30$, $P = .054$). The relationship with weight persisted when controlling for assigned intervention ($r = -.31$, $P = .048$). Controlling for baseline EC suggested an inverse relationship between EC change from baseline to month 12 and weight change from baseline to both months 4 and 12 ($r = -0.35, P = .025; r = -0.31$, $P = .049$) and with BMI from baseline to both months 4 and 12 ($r = -0.32, P = .04; r = -0.28, P = .075$). However, EC changes from baseline to month 4 were not associated with weight and BMI changes in the same time period, suggesting that EC change is not synchronous with weight and BMI changes. Of the 16 items on the ecSI, 3 decreased significantly and 9 either tended to decrease or were unchanged from baseline to month 4; of these 12, 8 increased significantly from month 4 to month 12 with none worsened during this time (Table 5).

Discussion

The WORLD study was designed to evaluate biomedical, psychological, and dietary changes of overweight/obese women participating in a 12-month lifestyle education and monitoring program. This report focused on EC changes and suggests that EC can be an important measure in impact assessment of weight management programs that are followed for 1 year or more. The WORLD study intervention, which reflected content congruent with the *Dietary Guidelines* and steeped in constructs related to motivation theory and cognitive behavior, incorporated educational strategies that facilitate deep learning, reflection, and dietary and physical activity self-efficacy. The WORLD study participation was associated with weight loss that leveled off after the hypocaloric phase. Concerns about unsustainable weight change and behavioral sequela from interventions focused on weight have led to suggestions for nondieting approaches that value metrics other than weight or BMI to measure intervention impact.[42] One such metric is EC because of its association with healthful weight, physical activity, diet quality, good sleep hygiene, and reduced cardiovascular risk factors. However, study of EC change, especially in relationship to changes in weight for interventions lasting 12 months or more, has been limited. Findings from studies of 4 other interventions with varying follow-up intervals are congruent with the WORLD study EC change from baseline to month 4. WebHealth, an online intervention seeking to improve diet quality in college students, showed little to no EC change from baseline to month 3 or month 15.[43] However, WebHealth was a less intense dietary and lifestyle, (not weight loss), intervention with no face-to-face individual, or group education component.

The EC change in a hospital-sponsored, 6-week weight loss class for adults did not fare much better than WebHealth. Outcomes included a significant reduction in weight ($P < .001$; n =

56), with increased weight satisfaction ($P < .001$) and perception of being physically active ($P < .02$), but no change in EC (unpublished data). The EC score did not change from the beginning (30.1 $\pm$ 6.9) to the end (30.1 $\pm$ 6.8) of a semester-long, mostly lecture-based, general nutrition college course (n = 334, 78 male, mean age 19.9 $\pm$ 2.4 years, >50 majors, 57% sophomores) that met weekly for three 50-minute sessions. In fact, eating attitude subscale scores worsened for males (12.7 $\pm$ 2.2 vs 12.2 $\pm$ 2.7; $P = .03$).[44] Unlike the college course, which did not specifically address EC, *About Eating*, a 5-lesson online program targeting low-income women, was specifically designed to target EC concepts in 4 of the lessons. A randomized, controlled trial included a comparison of outcomes from participation in either *About Eating* (n = 154) or a USDA Web site focused on healthful eating and food resource management concepts (n = 148) over a 4- to 7-week period. Despite showing some impact of *About Eating* on food resource management skills,[45] nonsignificant decreases in ecSI/LI scores were noted for both interventions and appeared driven by decreases in EAs and IR. In addition, the proportion of *About Eating* participants that were EC decreased from 42% at baseline to 32% at follow-up.[46] The WORLD study month 4 results were reflective of *About Eating's* lower scores at the 4 to 7 weeks of follow-up. Although a variety of reasons were suggested to account for *About Eating*'s EC decrease, (eg, short, <15-minute exposure to each *About Eating* lesson, a research design that prohibited revisiting *About Eating,* and attrition of participants with the greatest potential to improve), the decrease could have been a reflection of the increased anxiety and discomfort that initially accompany new dietary information and ideas.

Perceptions related to interventions, self, and environment may change over time. Wang et al measured perception of barriers to healthy eating over a 24-month weight loss intervention for a mostly female sample of premenopausal and perimenopausal overweight women. Fewer barriers were perceived during the intense contact phase from baseline to month 6 than during month 6 to month 24.[47] Barrier underestimation, that is, underestimating the difficulty of changing behavior, may explain decreased self-efficacy early in an intervention; self-efficacy is included in the EC construct. Baseline confidence may erode when realizing that assimilating new, suggested behaviors is more difficult than perceived.[48] How to approach barrier underestimation was suggested for inclusion in a behavioral intervention for weight loss.[49]

Contemplating change can be hampered by ambivalence, and once ambivalence is resolved, behavior change can move forward. Resistance is the default reaction to loss of choice or freedom potential. Resistance can be viewed as normal, not an indicator of poor prognosis.[50] Measurement of EC at month 4 could be viewed as a measure of response reactance to caloric restriction and advice for lifestyle change that involves restriction and loss of freedom. Ambivalence resolution requires intrinsic motivation and reflection with discussion on the part of the learner/client, not direct persuasion. Additional insight into behavior change suggests that early EC decline may not be unexpected because the individual is "someone constantly in the process of becoming, interacting with his or her context, relating to others, and developing over time."[51(pp. 1630–1631)] Adjustment/adaptation can be the result of something that happens to the individual or something they do or initiate. Transformation plays a role in improved health, that is, a qualitative change from a current state may be required to effect this improvement. Correlations between EC changes and weight changes suggested that improvement in EC with weight loss was affected by baseline EC. Perception of being EC at baseline may reflect naiveté about the upheaval encountered with suggested changes in eating and activity patterns.

Individual EC survey item response change from baseline to month 4 showed the dampened effect that accompanies calorie restriction and required increase in activity patterns during this period. Accommodation to the new eating and behavior pattern including resumption of a eucaloric diet was reflected in improved responses for items related to eating attitudes and behaviors. Decreases from baseline to month 4 dovetail with anticipated outcomes during a hypocaloric phase, that is, declines in enjoying eating, being comfortable with eating enough and assuming one will get enough to eat. Their reversal during the eucaloric phase as well as increases in feeling comfortable with enjoyment of eating and eating what one likes and taking more control of mealtime structure and composition during this phase suggested that hypocaloric and major lifestyle interventions may derail established self-perceptions that are recaptured and strengthened upon adaptation to lifestyle changes. The 4 items that increased from baseline to month 4 (Table 5) were compatible with expectations from the hypocaloric phase of an intervention designed to encourage new eating and physical activity patterns.

SO WHAT? Implications for Health Promotion Practitioners and Researchers

Eating competence (EC) is a construct aligned with public health nutrition goals related to weight, sleep, physical activity, diet quality, cognitive behavior, and quality of life. Impact assessment of interventions and programs focused on weight management and healthful lifestyles would benefit by measuring change in EC. However, only a few short-term studies have assessed EC and these have revealed no change or even a decline in EC in an otherwise successful program. This study is the first to measure EC change over a year after program implementation. Interim, short-term findings concurred that EC is unchanged or decreased, but after 1 year, EC was significantly improved. EC is a valuable outcome measure of weight management interventions, but accurate assessment requires long-term follow-up to overcome barrier underestimation and self-efficacy disturbances that occur shortly after interventions that restructure diet and lifestyle practices.

Limitations to the study include the relatively short follow-up and infrequent measurements to capture a more reactive profile. The sample was all female, from 1 geographic area that has a well-educated populace,[52] and those with extreme scores (eg, depression) and/or lipid/lipoprotein values were excluded. Thus, findings may not generalize to men, persons not in good general health or of lower socioeconomic position. In addition, the sample size was small; however, baseline EC of this sample reflected baseline values of larger studies consisting of all or nearly all women similar in age to the WORLD study sample[1,4,53] and affirmed earlier relationships of EC with several biopsychosocial measures.

This study indicated that traditional intervention impact on EC is better captured by a delayed rather than immediate postintervention measurement. In addition, considering the health proxy potential of EC, the increase in EC associated with weight loss, albeit asynchronous, suggests EC is a valuable outcome measure of weight management interventions.

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